

SECTION XIV

EIS APPENDICES

Appendix A: **Draft Fish and Wildlife Coordination Act Report**

Appendix B: **Greenup Endangered Species Act Coordination:**

- Part 1: Characterization of a *Unionid* Community along the Ohio bank near the Greenup L&D
- Part 2: Greenup L&D: Report of Findings—
 - Aquatic and Terrestrial Inventory and
 - Habitat Evaluation Procedure Analysis

Appendix C: **Myers Endangered Species Act Coordination**

Appendix D: **Clean Water Act: Section 404 (b)(1) Greenup Evaluation**

Appendix E: **Clean Water Act: Section 404 (b)(1) Myers Evaluation**

Appendix F: **Greenup Mitigation Plan and Incremental Analysis**

Appendix G: **Myers Mitigation Plan and Incremental Analysis**

Appendix H: **Air and Noise**

Appendix I: **Biological and Soil Data**

Appendix J: **Excavated Material Sampling Plan**

Appendix K: **Comments and Responses on the Draft EIS**

Appendix L: **Acronyms and Abbreviations**

Appendix M: **Glossary**

Appendix N: **Index**

Characterization of a Unionid Community along the Ohio bank near the Greenup Locks and Dam: Ohio River Miles 340.5 to 343.0

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Table of Contents

| | |
|--|----|
| 1.0 Introduction..... | 1 |
| 2.0 Methods..... | 3 |
| 3.0 Results and Discussion | 5 |
| 3.1 Habitat Characteristics and Sampling Conditions..... | 5 |
| 3.2 Unionid Fauna..... | 5 |
| 4.0 Conclusions and Recommendations..... | 13 |
| 5.0 Literature Cited..... | 14 |

List of Figures

| | |
|---|----|
| Figure 2-1. Diving locations near Greenup Locks and Dam (ORM 340.5 to 343.0), August 1999..... | 4 |
| Figure 3-1. Age distribution of all unionids found along the Ohio bank, ORM 340.5 to 343.0, August 1999..... | 12 |

List of Tables

| | |
|--|----|
| Table 1-1. Recent unionid species records in the upper Ohio River..... | 2 |
| Table 3-1. Habitat characteristics along transects on the Ohio River near Greenup Locks and Dam, (ORM 340.5 to 343.0), August 1999..... | 6 |
| Table 3-2. Unionid relative abundance and community characteristics near Greenup Locks and Dam, (ORM 340.5 to 343.0), August 1999..... | 7 |
| Table 3-3. Distribution of live unionids between ORM 340.5 to 343.0 on the Ohio bank. | 10 |
| Table 3-4. Comparison of unionid abundance and species composition along all transects..... | 11 |

1.0 Introduction

The U.S. Army Corps of Engineers (USCOE) proposes extending the lock wall at Greenup Locks and Dam on the Ohio River. With the improving water and sediment quality in recent years (Cavanaugh and Mitsch, 1989; Pearson and Pearson, 1989; Youger and Mitsch, 1989), unionids have begun to flourish in many areas of the Ohio River. Recent studies have recorded 41 living and recently dead species in the upper river, 30 of which are present in Meldahl Pool (Table 1-1). These unionid communities are often diverse, and the Federally listed species *Cyprogenia stegaria* and *Lampsilis abrupta* have been found in several areas (ESI, 1996a, 1996b, 1998a, and 1998b; Miller and Payne, 1995; P. Morrison-USFWS, pers. comm.).

USCOE is concerned that unionids may be affected by construction activities during lock wall modification. Unionids could be affected by construction activities in several ways. Unionids living in the construction area could be crushed or dislodged during sheet piling placement and removal, and lock wall construction. Cofferdam dewatering and removal may result in substrate disturbance and downstream siltation. Construction activities (such as staging equipment near banks and in the water, barge spudding, etc.) may also crush or dislodge animals, or disturb substrate and streambanks, possibly resulting in downstream sediment deposition. Additionally, fish host activity in a unionid bed may be altered by habitat changes and/or altered flow patterns. These activities pose the greatest threat to unionids on the Kentucky bank. ESI (1999) conducted a survey to characterize the unionid community in this area, finding a diverse and reproducing population downstream of the Greenup Locks and Dam, but no live Federally endangered species.

Across the channel, the Ohio side of the river near the Greenup Locks and Dam is situated on the outside bank of a riverbend. Outside bends have more consistent flow, and are less depositional than inside bends (ESI, 1997). Such areas are often more conducive to unionid communities, and similar distribution patterns have been found on the Ohio River downstream of Belleville Locks and Dam (ESI, 1998a) and on the upper Connecticut River in Vermont/New Hampshire (Marangelo, 1997). The existence of a diverse unionid community on an inside bend (ESI, 1999) suggested that a community of even greater diversity and/or abundance might occur in potentially superior habitat on the outside bend. Williams and Schuster (1989) found nine unionid species while brailing between ORM 342.0 and 343.5 along the Ohio bank, even though their sampling method was fairly inefficient. Therefore, USCOE contracted Burgess & Niple and Ecological Specialists, Inc. to conduct additional surveys for unionids along the right descending bank of the Ohio River upstream and downstream of Greenup Locks and Dam. The objective of this study was to determine unionid species composition, relative abundance, and distribution within the study area.

Table 1-1. Recent unionid species records in the upper Ohio River.

| Species ¹ | Common Name | Status ² | ORM 0 to 418.9 ^{3,4} | Meldahl Pool ^{3,5} |
|-----------------------------------|------------------------|---------------------|-------------------------------|-----------------------------|
| <i>Actinonaias ligamentina</i> | mucket | | L | L |
| <i>Amblema p. plicata</i> | threeridge | | L | L |
| <i>Cyclonaias tuberculata</i> | purple wartyback | | L | L |
| <i>Cyprogenia stegaria</i> | fanshell | FE,KYE,OE | L | |
| <i>Ellipsaria lineolata</i> | butterfly | OE | L | L |
| <i>Elliptio crassidens</i> | elephant-ear | OE | L | L |
| <i>Elliptio dilatata</i> | spike | | L | L |
| <i>Epioblasma t. torulosa</i> | tubercled blossom | FE,KYE | SF | |
| <i>Epioblasma triquetra</i> | snuffbox | C2,KYS | FD | |
| <i>Fusconaia ebena</i> | ebonyshell | | L | L |
| <i>Fusconaia flava</i> | Wabash pigtoe | | L | L |
| <i>Fusconaia subrotunda</i> | long-solid | OE,KYT | L | |
| <i>Lampsilis abrupta</i> | pink mucket | FE,KYE,OE | L | |
| <i>Lampsilis cardium</i> | plain pocketbook | | L | L |
| <i>Lampsilis ovata</i> | pocketbook | KYE,OE | L | L |
| <i>Lampsilis siliquoidea</i> | fatmucket | | L | L |
| <i>Lampsilis teres</i> | yellow sandshell | OE | L | L |
| <i>Lasmigona c. complanata</i> | white heelsplitter | | L | L |
| <i>Lasmigona costata</i> | fluted-shell | | L | |
| <i>Leptodea fragilis</i> | fragile papershell | | L | L |
| <i>Ligumia recta</i> | black sandshell | | L | L |
| <i>Megalonaia nervosa</i> | washboard | OE | L | L |
| <i>Obliquaria reflexa</i> | threehorn wartyback | | L | L |
| <i>Obovaria olivaria</i> | hickorynut | OE | SF | |
| <i>Obovaria retusa</i> | ring pink | FE,KYE | WD | SF |
| <i>Obovaria subrotunda</i> | round hickorynut | | L | |
| <i>Plethobasus cicatricosus</i> | white wartyback | FE | SF | |
| <i>Plethobasus cooperianus</i> | orange-foot pimpleback | FE,KYE,OE | WD | |
| <i>Plethobasus cyphus</i> | sheepnose | KYS,OE | L | L |
| <i>Pleurobema clava</i> | clubshell | FE,KYE,OE | SF | |
| <i>Pleurobema coccineum</i> | round pigtoe | | L | L |
| <i>Pleurobema cordatum</i> | Ohio pigtoe | OE | L | L |
| <i>Pleurobema plenum</i> | rough pigtoe | FE,KYE | SF | |
| <i>Pleurobema pyramidatum</i> | pyramid pigtoe | C2,KYE | SF | |
| <i>Potamilus alatus</i> | pink heelsplitter | | L | L |
| <i>Potamilus ohioensis</i> | pink papershell | | L | FD |
| <i>Ptychobranchus fasciolaris</i> | kidneyshell | | SF | |
| <i>Pyganodon grandis</i> | giant floater | | L | L |
| <i>Quadrula metanevra</i> | monkeyface | OE | L | L |
| <i>Quadrula nodulata</i> | wartyback | OE | L | L |
| <i>Quadrula p. pustulosa</i> | pimpleback | | L | L |
| <i>Quadrula quadrula</i> | mapleleaf | | L | L |
| <i>Simpsonaias ambigua</i> | salamander mussel | C2,KYT | FD | |
| <i>Strophitus undulatus</i> | squawfoot | | L | |
| <i>Toxolasma parvus</i> | lilliput | | L | |
| <i>Tritogonia verrucosa</i> | pistolgrip | | L | L |
| <i>Truncilla donaciformis</i> | fawnsfoot | | L | L |
| <i>Truncilla truncata</i> | deertoe | | L | L |
| <i>Utterbachia imbecillis</i> | paper pondshell | | L | |
| <i>Uniomerus tetralasmus</i> | pondhorn | | L | |
| Total Species | | | 50 | 31 |
| Species Live (L and FD) | | | 41 | 30 |
| Species Weathered (WD and SF) | | | 9 | 1 |

¹Nomenclature follows Turgeon *et al.* (1988) and Hoeh (1990)²FE=Federally Endangered (USFWS, 1996); C2=Former category 2 species (USFWS, 1991); KYE=Kentucky Endangered, KYT=Kentucky Threatened, KYS=Kentucky Species of Special Concern (Kentucky State Nature Preserves Commission, 1994); OE=Ohio Endangered (ODNR, 1995)³Best Condition; L=Live, FD=Freshly Dead Shell, WD=Weathered Shell, SF=Subfossil Shell⁴Taylor (1980), Tolim and Schettig (1983), Zeto *et al.* (1987), ESE (1995), ESI (1990, 1991, 1993, 1994a, 1994b, 1995a, 1996a, 1996b, 1997, 1998a, 1998b, 1998c), Miller and Payne (1995), P. Morrison (pers. comm.), W. Tolin (pers. comm.)⁵ESI (1998c), P. Morrison (pers. comm.)

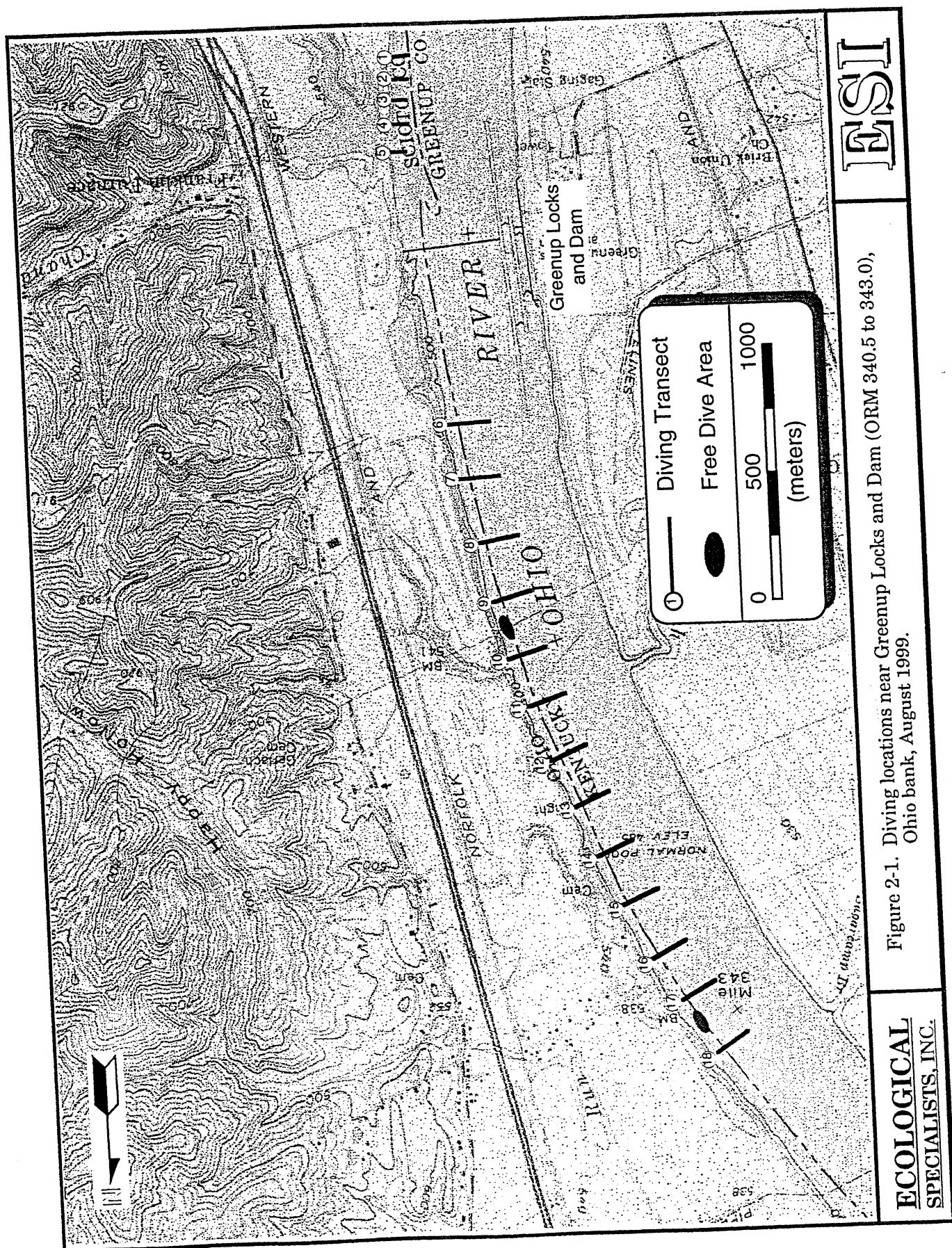
2.0 Methods

Unionids were sampled in the Ohio River along the Ohio bank upstream and downstream of Greenup Locks and Dam (ORM 340.5 to 343.0) between August 9 -14, 1999. The main objective of this study was to determine if Federally endangered species would be affected by this project. The effort required to find uncommon species is often considerable, and they are rarely collected in brail or quantitative samples (Kovalak *et al.*; 1986, Strayer *et al.*, 1997). Timed searches yield a better estimate of unionid species richness than quantitative samples (Strayer *et al.*, 1997; Vaughn *et al.*, 1997), as well as providing relative abundance per unit of effort. Semi-quantitative sampling (timed visual and tactful searches within a given area) are less time consuming and generally yield a greater number of unionids than quantitative samples, while providing a relative idea of unionid distribution (Dunn, in press). Therefore, semi-quantitative sampling was used to estimate species composition and distribution of the unionid community. Additional qualitative timed searches were conducted in areas of unionid concentrations to increase the probability of finding rare or endangered species.

Semi-quantitative sampling was conducted along transect lines laid perpendicular to the right descending riverbank (Figure 2-1). Upstream of Greenup Locks and Dam, water depth exceeded safe diving limits (12m) beyond 50m of the riverbank. Therefore, transects were limited to 50m long, but were spaced 100m apart from ORM 340.5 to the lock wall (five transects). Downstream of Greenup Locks and Dam, 13 - 150m long transects spaced 200m apart were established perpendicular to the bank between the downstream end of the lock wall and ORM 343.0. No sampling was conducted within the restricted area of the dam (see Figure 2-1). Transects were marked at 10m intervals, and each 1m corridor within each interval (1 x 10m) was searched visually and tactually for four minutes and treated as a separate sample. General substrate composition was visually characterized by the diver in each interval and relayed to the surface crew.

To better characterize the unionid community, additional qualitative sampling was conducted in areas of unionid concentrations (between Transects 9 – 10 and 17 –18) until 1000 or more live unionids were collected. Additionally, the entire shoreline from Transect 11 to 18 was searched for shells.

All live unionids were identified, measured (length in mm), aged (external annuli count), and weighed (grams). Empty shells were also collected, identified, and categorized as freshly dead (nacre still lustrous, probably died within the last year), weathered (nacre chalky, probably dead more than a few years), or subfossil (periostracum eroded or shell fragmented, probably dead >10 years).



3.0 Results and Discussion

3.1 Habitat Characteristics and Sampling Conditions

Habitat differed considerably upstream and downstream of the dam. Upstream, current velocity was <0.1 knots, and water depth averaged 7.1m within 50m of the bank, but was >12m at 50m. Substrate consisted primarily of fine depositional sediment mixed with small amounts of gravel (Table 3-1).

Downstream of the lock, water was shallower, averaging 3.7m (range 2 to 4.6m) within 50m of the bank, and 4.2 m (range 2.0 to 5.2m) between the bank and 150m. Current velocity was generally a function of distance from the hydropower outlet in the Greenup Dam on the Ohio bank. Current velocity ranged from <0.01 knots at transects farthest from the hydropower outlet to 1.7 knots at Transect 6, and varied in time in accordance with dam releases. Substrate generally was coarser downstream of the dam than upstream due to increased flow. Also, substrate characteristics varied with downstream distance from the dam and distance from the bank. Substrate was more heterogeneous within 50m of the bank, and contained finer sediment, particularly downstream of Transect 14, where influence of dam releases was minimal. Between 50 to 100m, substrate was primarily cobble, gravel, and sand. Beyond 100m substrate was mainly bedrock, boulder, and large cobble.

3.2 Unionid Fauna

A diverse and reproducing unionid bed exists within portions of the study area, but no Federally protected species were found. Overall, the study area yielded 16 live species and weathered dead shells of an additional four species (Table 3-2). Semi-quantitative sampling revealed distinct distribution patterns. Upstream of the dam, few live individuals or shells were collected along Transects 1 to 5 (Tables 3-3 and 3-4). This is likely due to the fine sediment and lack of flow associated with impoundment (Bates, 1962; Suloway *et al.*, 1981; ESI, 1995b). Downstream of the dam, most unionids were collected within 50m of the bank (see Table 3-3). Of the 197 live unionids of 13 species collected in semi-quantitative samples, 160 (81%) were found in this area. Also, CPUE averaged 6.95/10 minutes of search time, and density averaged 0.24/m² (see Table 3-3). Unionids were scarce along Transects 6 and 7, and most abundant along Transects 9 – 11, where 116 specimens (58% of total collected) were collected within 50m of the bank. Here CPUE averaged 19.3 unionids/10 min. and density averaged 0.77/m² (see Table 3-3). Transects 12 – 18 yielded moderate numbers of live unionids. Riverward of 50 m, substrate appeared unstable (gravel and sand) or consisted of less hospitable bedrock, boulder, and cobble (see Table 3-1), and only a few scattered individuals were found (see Table 3-3).

An additional 952 live unionids were collected during qualitative searches within 50m of the bank between Transects 9 - 10 and 17 – 18. This effort yielded live specimens of two species not found during the transect sampling (*Lampsilis ovata* and *Quadrula quadrula*).

Table 3-1. Habitat characteristics along transects on the Ohio River near Greenup Locks and Dam, (ORM 340.5 to 343.0), August 1999.

| Transect no. | Ave. depth(m) | Distance from bank(m) | | | | | | Dissolved | | |
|--------------|---------------|-----------------------------|------------------------|---------------|------------------------|----------------|------------------------|------------|--------------|-------------|
| | | 0-50 | | 50-100 | | 100-150 | | Temp. (C°) | Oxygen (ppm) | Secchi (mm) |
| | | Ave. Substrate ¹ | Substrate ¹ | Ave. depth(m) | Substrate ¹ | Ave. depth(m) | Substrate ¹ | | | |
| 1 | 7.13 | Gr/Sd/St | | | | | | 29 | 6.5 | >2000 |
| 2 | 6.86 | Gr/St/detritus | | | | | | 29 | 6.5 | >2000 |
| 3 | 6.77 | Gr/St/detritus | | | | | | 29 | 6.5 | >2000 |
| 4 | 7.44 | Sd/St/detritus | | | | | | 29 | 6.5 | >2000 |
| 5 | 7.32 | Gr/Sd/St | | | | | | 29 | 6.5 | >2000 |
| 6 | 4.33 | Br/Bd/Cb/Gr | 3.66 | Bd/Cb/Gr | 2.87 | Cb/Gr | 2.87 | 29 | 6.9 | >2000 |
| 7 | 3.66 | Cb/St | 4.88 | Bd | 5.06 | Bd | 5.06 | 29 | 6.9 | >2000 |
| 8 | 3.35 | Br/Bd/Cb/Gr/Sd/St | 5.12 | Br/Bd | 4.38 | Cb/Gr/Sd | 4.38 | 29 | 6.4 | >2000 |
| 9 | 4.18 | Bd/Cb/Gr/Sd/St | 5.18 | Br/Cb/Gr | 4.57 | Br/Bd/Cb/Gr | 4.57 | 29 | 6.4 | >2000 |
| 10 | 4.29 | Bd/Cb/Gr | 4.88 | Br/Bd/Cb/Gr | 4.88 | Br/Bd/Cb/Gr/Sd | 4.88 | 29 | 6.4 | >2000 |
| 11 | 4.65 | Bd/Cb/Gr/Sd | 4.57 | Br/Cb/Gr | 5.12 | Bd/Cb/Gr/Sd | 5.12 | 29 | 6.4 | >2000 |
| 12 | 4.05 | Cb/Gr/St | 4.06 | Bd/Gr/Sd | 4.45 | Bd/Gr | 4.45 | 29 | 6.4 | >2000 |
| 13 | 4.08 | Cb/Gr/Sd/St | 4.45 | Br/Cb/Gr | 4.63 | Br/Cb/Gr | 4.63 | 29 | 6.4 | >2000 |
| 14 | 3.77 | Cb/Gr/Sd | 4.57 | Br/Bd/Gr/Sd | 4.64 | Br/Bd/Gr/Sd | 4.64 | 27 | 6.6 | >2000 |
| 15 | 1.97 | Gr/Sd | 4.57 | Cb/Gr/Sd | 4.57 | Bd/Cb/Gr/Sd | 4.57 | 27 | 6.6 | >2000 |
| 16 | 3.54 | Bd/Gb/Gr/Sd | 4.27 | Gr/Sd | 4.27 | Bd/Cb/Gr/Sd | 4.27 | 27 | 6.6 | >2000 |
| 17 | 3.54 | Gr/Sd | 4.27 | Gr/Sd | 4.57 | Cb/Gr/Sd | 4.57 | 27 | 6.6 | >2000 |
| 18 | 3.11 | Gr/Sd | 3.61 | Bd/Bd/Gr/Sd | 4.61 | | | 27 | 6.6 | >2000 |
| Total | | | 4.35 | | | | 4.43 | | 4.51 | |

¹Br = bedrock, Bd = boulder, Cb = cobble, Gr = cobble, Sd = sand, St = silt

Table 3-2. Unionid relative abundance and community characteristics near Greenup Locks and Dam, (ORM 340.5 to 343.0), August, 1999.

| Species | No. | % Ave. | Age (years) | | | Length (mm) | | | Weight (g) | | |
|---------------------------------------|------|-----------|-------------|------|------|-------------|------|------|------------|------|-----|
| | | | Min. | Max. | Ave. | Min. | Max. | Ave. | Min. | Max. | |
| <i>Actinonaias ligamentina</i> | 2 | >1 | 10.0 | 5 | 15 | 94.0 | 75 | 113 | 121.5 | 85 | 158 |
| <i>Amblema p. plicata</i> | 147 | 13 | 8.5 | 3 | 28 | 74.1 | 27 | 133 | 137.6 | 10 | 512 |
| <i>Ellipsaria lineolata</i> (OE) | 62 | 5 | 5.7 | 3 | 10 | 59.5 | 38 | 80 | 66.7 | 15 | 158 |
| <i>Elliptio crassidens</i> (OE) | 9 | 1 | 18.9 | 14 | 25 | 105.4 | 95 | 121 | 278.6 | 240 | 360 |
| <i>Fusconaia ebena</i> | 2 | >1 | 15.5 | 6 | 25 | 65.0 | 42 | 88 | 195.0 | 40 | 350 |
| <i>Fusconaia flava</i> | 2 | >1 | 6.5 | 6 | 7 | 60.0 | 57 | 63 | 46.0 | 46 | 46 |
| <i>Fusconaia subrotunda</i> (OE, KYT) | WD | 0 | | | | | | | | | |
| <i>Lampsilis cardium</i> | 36 | 3 | 8.9 | 4 | 17 | 108.2 | 85 | 132 | 293.0 | 125 | 505 |
| <i>Lampsilis ovata</i> (OE, KYE) | 1 | >1 | 6.0 | 6 | 6 | 106.0 | 106 | 106 | 258.0 | 258 | 258 |
| <i>Lampsilis siliquoidea</i> | 3 | >1 | 10.7 | 5 | 16 | 99.0 | 78 | 118 | 214.7 | 100 | 402 |
| <i>Lepiodea fragilis</i> | 1 | >1 | 3.0 | 3 | 3 | 40.0 | 40 | 40 | 4.0 | 4 | 4 |
| <i>Ligumia recta</i> | 25 | 2 | 6.2 | 3 | 12 | 115.2 | 16 | 146 | 160.8 | 49 | 317 |
| <i>Megalania nervosa</i> (OE) | WD | 0 | | | | | | | | | |
| <i>Obliquaria reflexa</i> | 617 | 54 | 5.5 | 2 | 13 | 43.6 | 24 | 116 | 35.4 | 4 | 170 |
| <i>Pleurobema coccineum</i> | WD | 0 | | | | | | | | | |
| <i>Pleurobema cordatum</i> (OE) | WD | 0 | | | | | | | | | |
| <i>Potamilus alatus</i> | 24 | 2 | 5.7 | 4 | 8 | 93.0 | 43 | 118 | 84.6 | 32 | 130 |
| <i>Quadrula metanevra</i> (OE) | 24 | 2 | 7.5 | 3 | 15 | 59.5 | 28 | 81 | 84.4 | 8 | 190 |
| <i>Quadrula p. pustulosa</i> | 181 | 16 | 7.2 | 2 | 14 | 44.7 | 21 | 76 | 49.4 | 5 | 130 |
| <i>Quadrula quadrula</i> | 13 | 1 | 9.8 | 5 | 13 | 61.4 | 39 | 71 | 82.3 | 25 | 118 |
| Total | 1149 | 6.5 | 2 | 28 | 54.5 | 16 | 146 | 69.1 | 4 | 512 | |
| Total ≤ 5 years of age | 507 | | | | | | | | | | |
| Total ≤ 3 years of age | 57 | | | | | | | | | | |

OE = Ohio endangered, KYT = Kentucky endangered, KYT = Kentucky threatened

Some of the variation in abundance downstream of the dam within 50m of the bank can be explained by the hydrology associated with dam releases from the hydropower turbines near the Ohio bank. The relative lack of unionids downstream of the lock and dam area along Transects 6 and 7 is probably due to effects of dam releases on substrate characteristics. During low flow, most of the discharge from the dam is through the hydropower turbines located near the Ohio bank. Flow out of the turbines appears to be directed at an angle toward the Kentucky bank, and turbulent conditions predominate on the Ohio bank downstream until about Transect 7. This flow pattern probably scours out the areas around Transects 6 - 7, thus creating unstable/hard substrate conditions unfavorable for unionids. This is consistent with the trend in particle sizes, which generally appear to decrease from upstream to downstream inside of 50m from the bank (see Table 3-1).

Unionid distribution patterns in the study area are hardly surprising, given that unionids are usually more abundant near the bank in large rivers than in the river channel (Way *et al.*, 1989; Miller and Payne, 1993; ESI, 1994c). Additionally, unionid beds are usually found in areas of stable sand, gravel, and cobble substrate, which is typically indicative of suitable unionid habitat (Strayer and Ralley, 1991; Vaughn, 1997). The greater amount of sedimentary material near the bank, and a preponderance of bedrock near the channel, suggests that substrate is more suitable for unionids near the bank, except for the areas affected by dam releases.

Although no live Federally listed species were collected, a subfossil shell of the Federally endangered *Obovaria retusa* was collected during the survey of the Kentucky bank (ESI, 1999). Four live species listed as endangered in Ohio or Kentucky were collected during this survey (*Ellipsaria lineolata*, *Elliptio crassidens*, *Quadrula metanervia*, and *Lampsilis ovata*). Weathered dead shells of Kentucky/Ohio protected *Megalonaia nervosa*, *Pleurobema cordatum*, and *Fusconaia subrotunda* were also collected. *Obliquaria reflexa* (54%), *Quadrula p. pustulosa* (16%), and *Amblema p. plicata* (13%) dominated the community (Table 3-2). *Ellipsaria lineolata* (5%), *Lampsilis cardium* (3%), *Ligumia recta* (2%), *Potamilus alatus* (2%) *Quadrula metanervia* (2%) were also relatively common, while the remaining species comprised 1% or less of the community. One species collected in this study is relatively uncommon in the upper Ohio River (*L. ovata*). Conversely, *Lasmigona c. complanata*, a species usually found in the upper Ohio River, was absent in this study.

Young animals (≤ 5 years old; 44% of all live individuals) and juveniles (≤ 3 years old; 5% of all live individuals) were fairly common in the study area, whereas older animals were scarce (Figure 3-1). This demographic pattern appears to be indicative of a developing unionid bed. The methods used in this study (semi-quantitative and qualitative) are typically biased toward larger animals, and juveniles are generally under represented in samples (Payne *et al.*, 1997; Vaughn *et al.*, 1997). Therefore it is

remarkable that juvenile unionids were so common, indicating that successful recruitment is occurring for at least 11 species. Conversely, older unionids (>15 years) were fairly scarce (see Figure 3-1). Thus the age of all sampled animals averaged only 6.1 years (see Table 3-2). Similar age distribution occurs in a unionid bed downstream of the Belleville Locks and Dam, and density has steadily increased in that bed over the past five years (ESI, 1998a).

Table 3-3. Distribution of live unionids between ORM 340.5 to 343.0 on the Ohio bank. Average density of the shaded area is 0.77/m². Average density of all areas sampled is 0.09/m².

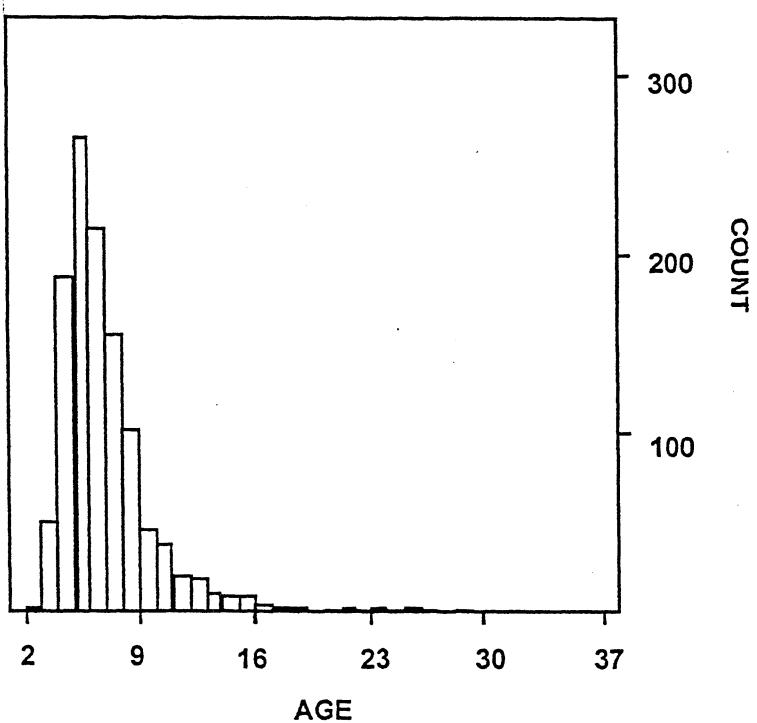
| Dist. from bank (m) | Transect | | | | | | | | | | | | | | | | | | Total | Ave. den. 1 - 5 | Ave. den. 5 - 18 |
|------------------------|----------|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|-------|--------------------|---------------------|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | | | |
| 0-10 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 4 | 0 | 7 | 1 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 16 | | |
| 10-20 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 5 | 0 | 16 | 8 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 32 | | |
| 20-30 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 6 | 21 | 13 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 46 | 0.03 | |
| 30-40 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 14 | 4 | 10 | 2 | 0 | 2 | 4 | 0 | 1 | 1 | 42 | | |
| 40-50 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 15 | 0 | 1 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 24 | | |
| 50-60 | | | | | | | | | | | | | | | | | | | | | |
| 60-70 | | | | | | | | | | | | | | | | | | | | | |
| 70-80 | | | | | | | | | | | | | | | | | | | | | |
| 80-90 | | | | | | | | | | | | | | | | | | | | | |
| 90-100 | | | | | | | | | | | | | | | | | | | | | |
| 100-110 | | | | | | | | | | | | | | | | | | | | | |
| 110-120 | | | | | | | | | | | | | | | | | | | | | |
| 120-130 | | | | | | | | | | | | | | | | | | | | | |
| 130-140 | | | | | | | | | | | | | | | | | | | | | |
| 140-150 | | | | | | | | | | | | | | | | | | | | | |
| Total | 3 | 2 | 1 | 0 | 1 | 4 | 1 | 17 | 35 | 52 | 34 | 4 | 2 | 10 | 10 | 7 | 9 | 5 | 197 | | |

Table 3-4. Comparison of unionid abundance and species composition along all transects.

| Species | Transect | | | | | | | | | | | | | | | Total | | | |
|--|----------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|-------|------|------|-----|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | |
| <i>Actinonaias ligamentina</i> | | | | | | | | | | | | | | | | WD | WD | 1 | 1 |
| <i>Ambloema p. plicata</i> | 2 | 2 | | | 1 | | 1 | 11 | 10 | 3 | 5 | 2 | | 1 | 1 | 1 | 1 | 39 | |
| <i>Ellipsaria lineolata</i> (OE) | | | | | | | | 2 | 1 | | 1 | | | | | | | 4 | |
| <i>Elliptio crassidens</i> (OE) | | | | | | | | | | | | | | | | | | 7 | |
| <i>Fusconaia ebena</i> | | | | | | | | | | | | | | | | | | 1 | |
| <i>Fusconaia flava</i> | | | | | | | | | | | | | | | | | | 1 | |
| <i>Fusconaia subrotunda</i> (OE,KYT ¹) | | | | | | | | | | | | | | | | | | WD | |
| <i>Lampsilis carolinum</i> | | | | | | | | | | | | | | | | | | WD | |
| <i>Lampsilis siliquoidea</i> | | | | | | | | | | | | | | | | | | WD | |
| <i>Leptodea fragilis</i> | | | | | | | | | | | | | | | | | | WD | |
| <i>Ligumia recta</i> | 1 | | | | | | | 1 | 2 | 2 | | | | 2 | | 1 | 1 | 1 | 11 |
| <i>Megalonaias nervosa</i> (OE) | | | | | | | | | | | | | | | | | | WD | |
| <i>Obliquaria reflexa</i> | 1 | | 1 | | | | | 2 | 15 | 31 | 20 | 1 | 1 | 3 | 2 | 4 | 1 | 82 | |
| <i>Pleurobema coccineum</i> | | | | | | | | | | | | | | WD | | | | WD | |
| <i>Pleurobema cordatum</i> (OE) | | | | | | | | | | | | | | | WD | WD | | WD | |
| <i>Potamilus clatus</i> | | WD | WD | WD | | 1 | | 1 | 2 | 2 | 1 | WD | | 1 | | WD | | 8 | |
| <i>Quadrula metaneura</i> (OE) | | | | | | | | | | | 3 | 1 | | 1 | 2 | 1 | 1 | 9 | |
| <i>Quadrula p. pustulosa</i> | | | | | | | | | | | 4 | 7 | 3 | | 1 | 1 | WD | 2 | 20 |
| <i>Quadrula quadrula</i> | | | | | | | | | | | | | | WD | WD | WD | | FD | |
| Total | 3 | 2 | 1 | 0 | 1 | 4 | 1 | 17 | 35 | 52 | 34 | 4 | 2 | 10 | 10 | 7 | 9 | 5 | 197 |
| No. Live Species | 2 | 1 | 1 | 0 | 1 | 3 | 1 | 4 | 7 | 8 | 8 | 3 | 2 | 7 | 6 | 4 | 7 | 4 | 13 |
| Total Species | 2 | 3 | 2 | 1 | 1 | 3 | 1 | 4 | 7 | 8 | 8 | 5 | 2 | 11 | 11 | 10 | 7 | 4 | 19 |
| CPUE (No./10min.) | 1.50 | 1.00 | 0.50 | 0.00 | 0.50 | 0.67 | 0.17 | 2.83 | 5.83 | 8.67 | 5.67 | 0.67 | 0.33 | 1.67 | 1.67 | 1.17 | 1.50 | 0.83 | |
| Density (No./m ²) ¹ | 0.06 | 0.04 | 0.02 | 0.00 | 0.02 | 0.03 | 0.01 | 0.11 | 0.23 | 0.35 | 0.23 | 0.03 | 0.01 | 0.07 | 0.07 | 0.05 | 0.06 | 0.03 | |

¹Approximate density based on 5 1x10m qualitative samples along Transects 1 - 5 and 15 1x10 qualitative samples per transect along Transects 6 - 18.

FD = freshly dead, WD = weathered dead
OE = Ohio endangered, KYT = Kentucky threatened



ECOLOGICAL
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Figure 3-1. Age distribution of all unionids found along the Ohio bank, ORM 340.5 to 343.0, August 1999.

ESI

4.0 Conclusions and Recommendations

Unionids appear to be located primarily in suitable substrate areas downstream of the Greenup Locks and Dam, primarily within 50m of the bank and between Transects 9 – 11. The large proportion of juveniles in the population suggests that the unionid community is generally healthy and demographically vigorous. Although density appears to be low, species richness was relatively high (16 species), and recent recruitment is apparent. No Federally endangered species were collected. However, Federally endangered species have been collected in other upper Ohio River beds (ESI, 1998a) with similar characteristics (low density, high species richness, and evidence of reproduction), and several species that are rare in the upper Ohio River and/or are protected by Kentucky and/or Ohio were found. Thus it is possible that Federally endangered species may be present, but extremely rare (<0.01% of the community).

This concentration of unionids along the Ohio bank will probably not be affected by this project since it is located at least 1500m downstream of the dam and is on the /other side of the river from the lock. However, this bed should be considered in project planning.

Given that the opposite bank (situated on the inside of a riverbend) supports a more diverse community of unionids (18 species; ESI 1999), it was somewhat surprising that the present study found fewer individuals and fewer species along the outside bed, which is typically superior habitat. However, flow is diverted toward the Kentucky bank by the hydropower facility, scouring the substrate immediately downstream of the dam, and supplying flowing water to an otherwise depositional area on the Kentucky bank. Nevertheless, the Ohio bank of the Ohio River appears to support a reproducing unionid bed, and young animals were a much larger proportion of the population than along the Kentucky bank (44% vs. 8%). If zebra mussels do not severely impact unionids in the study area, it could potentially develop into a diverse high density bed.

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Report of Findings
Aquatic and Terrestrial Inventory and
Habitat Evaluation Procedure Analysis

Greenup Locks and Dam

U.S. Army Corps of Engineers



June 1999



BURGESS & NIPLE

**REPORT OF FINDINGS
AQUATIC AND TERRESTRIAL INVENTORY
HABITAT EVALUATION PROCEDURE ANALYSIS
GREENUP LOCKS AND DAM**

**Prepared by
BURGESS & NIPLE, LIMITED
JUNE 1999**

ERRATA

- Page vi (Executive Summary), Paragraph 3: The opening sentence should read “Six (not seven) *principal habitat types....*”
- Page vii (Executive Summary): The last sentence should read “*A total of 518.258 (not 629.235) HUs were calculated for terrestrial habitat...*”
- Page 54 (Table 29): The HSI value for Eastern Cottontail should read 0.400 (not 0.833), resulting in an HU value for Eastern Cottontail of 33.200 (not 69.139). The HU value for All Species should read 518.258 (not 629.235).

**REPORT OF FINDINGS
GREENUP LOCKS AND DAM IMPROVEMENTS**

AQUATIC AND TERRESTRIAL INVENTORY

AND

HABITAT EVALUATION PROCEDURE ANALYSIS

DACW69-97-D-0019 WORK ORDER 0009

PREPARED FOR

**U.S. ARMY CORPS OF ENGINEERS
HUNTINGTON DISTRICT
502 EIGHTH STREET
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JUNE 1999

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TABLE OF CONTENTS

| | Page |
|---|-------------|
| EXECUTIVE SUMMARY | vi |
| 1.0 INTRODUCTION | 1 |
| 1.1 Project Background | 1 |
| 1.2 Project Objectives | 1 |
| 1.3 Location | 1 |
| 1.4 Definition of Study Area | 3 |
| 1.5 Site History and Facilities | 3 |
| 2.0 METHODS | 4 |
| 2.1 Terrestrial Ecology | 4 |
| 2.1.1 Flora | 4 |
| 2.1.2 Fauna | 5 |
| 2.2 Aquatic Ecology | 6 |
| 2.2.1 Vertebrates | 6 |
| 2.2.2 Macroinvertebrates | 7 |
| 2.2.3 Unionids | 7 |
| 2.2.4 Water Quality | 7 |
| 2.3 Threatened and Endangered Species | 8 |
| 3.0 LITERATURE REVIEW | 9 |
| 3.1 Topography and Land Use | 9 |
| 3.2 Geology | 9 |
| 3.3 Soils | 9 |
| 3.4 Present Land Use Practices | 10 |
| 3.5 Terrestrial Resources | 10 |
| 3.5.1 Historical Terrestrial Resources | 10 |
| 3.5.2 Recent Terrestrial Survey Results | 11 |
| 3.6 Aquatic Resources | 11 |
| 3.6.1 Historical Aquatic Resources | 11 |
| 3.6.2 Recent Aquatic Survey Results | 12 |
| 3.7 Threatened and Endangered Species | 12 |

TABLE OF CONTENTS (Continued)

| | Page |
|--|-------------|
| 4.0 RESULTS | 16 |
| 4.1 Terrestrial Ecology | 16 |
| 4.1.1 Terrestrial Inventory Species Lists | 18 |
| 4.2 Aquatic Ecology | 21 |
| 4.2.1 Aquatic Habitats and Fish Communities | 22 |
| 4.2.2 Macroinvertebrates | 24 |
| 4.2.3 Unionids | 25 |
| 4.2.4 Aquatic Species Inventory Lists | 25 |
| 4.2.5 Water Quality | 28 |
| 4.3 Threatened and Endangered Species | 29 |
| 4.3.1 Indiana Bat Survey | 29 |
| 4.3.2 Mussel Survey | 30 |
| 5.0 BASELINE HEP ASSESSMENT | 31 |
| 5.1 Methodology | 31 |
| 5.2 Habitat Maps | 33 |
| 5.3 Guilding | 34 |
| 5.4 Evaluation Species | 41 |
| 5.5 Habitat Suitability Indices (HSIs) | 45 |
| 5.6 Baseline Habitat Units (HUs) | 53 |
| 6.0 LITERATURE CITED | 56 |

LIST OF FIGURES

| Figure | Description | Page |
|---------------|--------------------------|-------------|
| 1 | Site Location/Study Area | 2 |
| 2 | Terrestrial Habitat Map | 17 |
| 3 | Aquatic Habitat Map | 23 |

TABLE OF CONTENTS (Continued)

LIST OF TABLES

| Table | Description | Page |
|--------------|--|-------------|
| 1 | Ohio Heritage Program, terrestrial species with reported occurrences. | 14 |
| 2 | Kentucky Heritage Program, terrestrial species with reported occurrences. | 14 |
| 3 | Ohio Heritage Program, aquatic species with reported occurrences. | 14 |
| 4 | Kentucky Heritage Program, aquatic species with reported occurrences. | 15 |
| 5 | Terrestrial animal species, May 1999. | 18 |
| 6 | Terrestrial plant species, May 1999. | 20 |
| 7 | Fish species, May 1999. | 26 |
| 8 | Macroinvertebrates species, May 1999. | 27 |
| 9 | Mussel species, May 1999. | 28 |
| 10 | Average water quality conditions, aquatic habitat areas. | 29 |
| 11 | Land use/habitat type classification and compartments, target year: baseline. | 33 |
| 12 | Results of guilding species observed in terrestrial riparian forest habitat. | 35 |
| 13 | Results of guilding species observed in the terrestrial river bank habitat. | 36 |
| 14 | Results of guilding species observed in the terrestrial open field habitat. | 37 |
| 15 | Results of guilding species observed in aquatic backwater habitats. | 38 |
| 16 | Results of guilding species observed in aquatic lower riverine habitats. | 39 |
| 17 | Results of guilding species observed in aquatic upper riverine habitats. | 40 |
| 18 | Evaluation species selected specifically as representative species for each terrestrial habitat type for the HEP analysis. | 42 |
| 19 | Evaluation species selected specifically as representative species for each aquatic habitat type for the HEP analysis. | 43 |

TABLE OF CONTENTS (Continued)

LIST OF TABLES (Continued)

| Table | Description | Page |
|--------------|---|-------------|
| 20 | HEP evaluation species evaluated for each habitat type on the study area, target year: baseline. | 44 |
| 21 | HSI models used to evaluate the habitat. | 45 |
| 22 | Habitat compartment HSI evaluation for Riparian Forest Compartment 1 | 47 |
| 23 | Habitat compartment HSI evaluation for River Bank Compartment 2-1 | 48 |
| 24 | Habitat compartment HSI evaluation for River Bank Compartment 2-2 | 49 |
| 25 | Habitat compartment HSI evaluation for Open Field Compartment 3 | 50 |
| 26 | Habitat compartment HSI evaluation for Backwater Compartment 5 | 51 |
| 27 | Habitat compartment HSI evaluation for Lower Riverine Compartment 6 | 52 |
| 28 | Habitat compartment HSI evaluation for Upper Riverine Compartment 7 | 53 |
| 29 | Baseline conditions HUs for each evaluation species for each terrestrial habitat type on the study area and for the entire study area | 54 |
| 30 | Baseline conditions HUs for each evaluation species for each aquatic habitat type on the study area and for the entire study area | 55 |

LIST OF APPENDICES

| Appendix | Description |
|-----------------|--|
| A | Scientific Wildlife Collecting Permit |
| B | Ecological Specialists, Inc. – Unionid Community Characterization |
| C | BHE Environmental, Inc. – Indiana Bat Survey |
| D | COE Unpublished Report – Terrestrial Inventory for Greenup Lakes and Dam |
| E | ORSANCO Information – Aquatic Sampling in Ohio River |
| F | Terrestrial/Aquatic Habitat Photographs |
| G | Aquatic Voucher Photographs |

EXECUTIVE SUMMARY

Burgess & Niple, Limited (B&N) was retained by the U.S. Army Corps of Engineers (COE), Huntington District to complete terrestrial and aquatic species inventories and baseline Habitat Evaluation Procedure (HEP) Assessments for proposed improvements to the Greenup Locks and Dam on the Ohio River at Greenup, Kentucky. The work was completed under Contract No. DACW69-97-D0019 Work Order 0009. The objective of the terrestrial and aquatic inventories and HEP assessments is to provide data on baseline conditions at the site. Data will be used to assess environmental impacts and mitigation requirements associated with the various alternatives for proposed lock and dam improvements, in accordance with National Environmental Policy Act (NEPA) requirements. The site is located at the Greenup Locks and Dam at River Mile (RM) 341.0 on the Ohio River. The Greenup Locks and Dam are located approximately 4 miles north of Greenup, Kentucky, and approximately 20 miles north of Ashland, Kentucky.

B&N biologists collected all ecological survey data with assistance from Ecological Specialists, Inc. (ESI), of St. Peters, Missouri; BHE Environmental, Inc. (BHE), of Cincinnati, Ohio; and ENSR of Lafayette, Louisiana. Unionid collections were performed by biologists from ESI. The Indiana Bat (*Myotis sodalis*) survey was performed by BHE of Cincinnati, Ohio. ENSR assisted in the terrestrial survey and HEP Assessments.

Seven principal habitat types were identified in the terrestrial and aquatic study area including Open Field with an areal extent of 83 acres, Riparian Forest with an areal extent of 47 acres, River Bank Habitat with an areal extent of 9 acres, Upstream Riverine with an areal extend of 40 acres, Downstream Riverine with areal extent of 216 acres, and Backwater Habitat with areal extent of 23 acres. A total of 39 bird, 12 mammal, 2 reptile/amphibian, 68 plant, 29 fish, 24 unionid mussel species, and 20 macroinvertebrate taxa were collected during the survey. The mist net survey did not confirm the presence of federally endangered Indiana Bat. Habitat potential was assessed as low to moderate, with scattered large cottonwoods in the mature woods, located outside the study area, providing the most likely potential roosting habitat. The mussel portion of the aquatic inventory identified the federally endangered mussel, ring pink. The species was collected as a subfossil shell which is characterized as being dead for 10 or more years.

A modified/abbreviated HEP analysis was conducted on the study area to provide repeatable, quantified indices that can be used to evaluate the quality of the habitat for wildlife and a basis for mitigation needs. The Pennsylvania Modified HEP (PAM HEP) methodology formed the basis of the subject HEP analysis; however, the process was abbreviated in that not all PAM HEP forms were prepared, and in that the procedures were restricted to address only baseline existing conditions. A Habitat Unit (HU) is defined as the equivalent of 1.0 acres of habitat with a Habitat Suitability Index (HSI) value of 1.0 (optimal habitat). HUs are calculated for compartments as the product of the HSI in the compartment ($HUs = HSI \times \text{acres}$). Because an HU is an equivalent measure, 1.0 HU may be represented by 1.0 acres of habitat with an HSI of 1.0, 2.0 acres of habitat with an HSI of 0.5, or any other combination with a product of 1.0. A total of 629.235 HUs were calculated for terrestrial habitat and a total of 524.925 HUs were determined for aquatic habitat in the study area.

1.0 INTRODUCTION

1.1 Project Background

B&N was retained by the U.S. COE, Huntington District to complete terrestrial and aquatic species inventories and baseline HEP Assessments for proposed improvements to the Greenup Locks and Dam on the Ohio River at Greenup, Kentucky. The work was completed under Contract No. DACW69-97-D-0019 Work Order 0009.

The project is part of the Ohio River Main Stem Study, a comprehensive evaluation of maintenance, rehabilitation, construction, and habitat restoration needs for the Ohio River navigation infrastructure system. Preliminary traffic congestion and economic analysis data has indicated the need for an Interim Ohio River Main Stem Study and Report to address short-term needs at the Greenup Locks and Dam and John T. Myers Locks and Dam in Mount Vernon, Indiana.

1.2 Project Objectives

The objective of the terrestrial and aquatic inventories and HEP assessments is to provide data on baseline conditions at the site. Data will be used to assess environmental impacts and mitigation requirements associated with the various alternatives for proposed lock and dam improvements, in accordance with NEPA requirements.

1.3 Location

The site is located at the Greenup Locks and Dam at RM 341.0 on the Ohio River. The Greenup Locks and Dam are located approximately 4 miles north of Greenup, Kentucky, and approximately 20 miles north of Ashland, Kentucky. A site location map is provided as Figure 1.

1.4 Definition of Study Area

The terrestrial inventory study area encompassed approximately 166 acres of Corps lands on the west bank (Kentucky side) of the Ohio River at the Greenup Locks and Dam, Kentucky. In addition, an approximately 500-foot corridor of adjacent land between RM 340.5 and RM 343.0 was also inventoried.

The aquatic inventory study area encompassed 2.5 miles in the Ohio River main stem, extending from RM 340.5 just south of the Greenup Locks and Dam north to RM 343.0.

Study area limits are shown on Figure 1.

1.5 Site History and Facilities

The Greenup locks were constructed in 1954 and placed into full operation in 1959. Construction of the dam began in 1958, and the dam pool was raised to full height in 1962. There are currently two parallel locks. The main lock chamber is 110 feet wide by 1,200 feet long, and the auxiliary lock chamber is 110 feet wide by 600 feet long. The dam is a nonnavigable, high-lift, gated dam, top length 1,287 feet, including 245-foot fixed weir with 223-foot open crest. State Route 10 crosses the river above the dam on the Jesse Stuart Highway Bridge. A 70,000-kilowatt hydroelectric plant located at the dam is operated by the City of Vanceburg, Kentucky. A recreation area is also located at the locks and dam. A natural gas transmission pipeline operated by Tennessee Gas Company runs through a portion of the study area, culminating in an aerial pipeline river crossing approximately 1/2 mile north of the locks and dam.

2.0 METHODS

This section describes methodologies used to characterize terrestrial and aquatic ecology and the potential for occurrence of threatened and endangered (T&E) species in the study area. Results are presented in the Literature Review and Results sections following.

Available background data was reviewed prior to initiation of fieldwork. Sources of background data reviewed include U.S. Geological Survey (USGS) topographic maps, National Wetlands Inventory (NWI) maps, natural heritage data available from the Ohio Department of Natural Resources (ODNR) and Kentucky State Nature Preserves Commission (KSNPC), available previous environmental assessment reports, and available background information regarding operation of the locks and dam.

B&N biologists collected all ecological survey data with assistance from ESI of St. Peters, Missouri; BHE of Cincinnati, Ohio; and ENSR of Lafayette, Louisiana. Unionid collections were performed by biologists from ESI. The Indiana Bat (*Myotis sodalis*) survey was performed by BHE of Cincinnati, Ohio. ENSR assisted in the terrestrial survey and HEP Assessments.

A Kentucky Scientific Wildlife Collecting Permit was issued for the work by The Kentucky Department of Fish & Wildlife Resources May 6, 1999. A copy of the permit is included in Appendix A.

2.1 Terrestrial Ecology

The terrestrial survey included an inventory and a description of flora and fauna in all habitat types.

2.1.1 Flora

Identification of the terrestrial communities and their characteristics is necessary to determine construction impacts to the terrestrial ecology of the study area. Terrestrial communities were investigated May 10 through May 14, 1999. B&N reviewed previous documentation of vegetation within the study area prior to initiating fieldwork and delineated vegetative cover types (habitat types), including herbaceous vegetative land, on aerial photographs. B&N scientists then field-verified the aerial photograph interpretation. Dominant plant species and vegetation size and density were recorded for each cover type. Specifically, one 30-foot radius sample point for each vegetative cover type was chosen for

recording plant species and vegetation size and density. Sample points were chosen as being representative of the habitat. Each sample point was searched until no additional species were discovered. Vascular plant species were identified using appropriate botanical works of the region, but nomenclature conforms to Kartesz (1994a, b) and Reed (1988). Species abundance was visually estimated. Habitats were then classified based on *Plant Communities of Ohio: A Preliminary Classification and Description* (Anderson, 1981) and *Classification of Wetlands and Deepwater Habits of the United States* (Cowardin et al., 1979).

2.1.2 Fauna

Qualitative faunal surveys were completed concurrently with the vegetation survey using direct observation when possible, including mist net surveys and live trapping. In cases where direct observation was not possible, other indicators were used, i.e., vocalizations, skeletons, nests and burrows, scat, and tracks. Nomenclature for herpetofauna and mammals was provided by Banks et al. (1987). Avifauna nomenclature conforms to the American Ornithologists Union (1983, 1985, 1987, and 1989).

Mist net sites were selected to be representative of each habitat type and placed in likely flyway corridors for bird species. Nets were 8.5 feet high by 40 feet wide and constructed of black nylon mesh with 1.2-inch (30-millimeter) openings. A total of six nets were deployed in the three principal habitat types: open field, riparian forest, and river bank habitat. Nets were deployed from daylight to dusk for a period of 2 days and rolled up at night. Nets were checked frequently during the course of the day and captured individuals were identified and released.

Live traps were used to sample small mammal populations difficult to observe directly or through tracks and other sign. Live traps were 2-inch by 2-inch by 6.5-inch folding aluminum traps baited with rolled oats. A total of 300 traps were deployed in four principal habitat types over a period of 3 days and 2 nights. Traps were placed along transects in groups of five spaced approximately 60 feet apart. Traps were checked frequently during the day. Traps were left overnight and checked the following morning at daylight. Captured individuals were identified and released.

2.2 Aquatic Ecology

An aquatic inventory to document baseline conditions within the Ohio River in the vicinity of the Greenup Locks and Dam between RM 340.5 and RM 343 was conducted by B&N in conjunction with ESI of St. Peters, Missouri, on May 17, 18, 19, and 20, 1999. The aquatic inventory was conducted along the west shore of the Ohio River in Greenup County, Kentucky. The results of the qualitative survey were used to compile aquatic species inventory lists for vertebrates (fish), macroinvertebrates, and unionid mussels. Habitat and water quality data between RMs 340.5 and RM 343 were also collected during the survey.

Both field and laboratory methodologies used during performance of the aquatic inventory for Greenup Locks and Dam were consistent with the Ohio Environmental Protection Agency's (EPA's) *Biological Criteria for the Protection of Aquatic Life: Volume III: Standardized Biological Field Sampling and Laboratory Methods for Assessing Fish and Macroinvertebrate Communities* (Ohio EPA, 1989).

2.2.1 Vertebrates

The aquatic vertebrate inventory was completed using boat-mounted electrofishing equipment and a circular electrode array. The boat was equipped with a generator, Coffelt electrofishing unit, and a positive pressure cut-off foot pedal switch. Electrofishing was conducted in an upstream to downstream direction using a zigzag pattern along the shoreline. The entire area from RM 340.5 to RM 343 was sampled on both Tuesday, May 18, and Wednesday, May 19, 1999, for a total of two electrofishing passes over the study area. Habitat areas were sampled in 100-meter intervals for the upstream portion and 200-meter intervals for the downstream portion. Fish were netted using dip nets and immediately placed in a live well for identification at the end of each electrofishing zone. All vertebrate individuals were identified at the site and returned to the Ohio River following identification. Voucher samples of species not able to be identified in the field were preserved in 10-percent formalin and returned to the lab for identification. Voucher photographs were taken in the field where possible for documentation of species collected during the inventory. Taxonomic identification and distribution information followed Trautman (1981) and Page and Burr (1991).

2.2.2 Macroinvertebrates

Macroinvertebrate sampling was conducted on Thursday, May 20, 1999, using a manual Ponar Grab to collect bottom samples within different habitat areas. Each grab sample was transferred to a tub which was poured through a wash bucket with a No. 30-mesh (600-micrometer [μm]) stainless steel wire cloth to retain the sample. All material collected from a grab was preserved in 10-percent formalin and transported back to the lab for processing and identification. In the lab, all samples were rinsed with water and passed through No. 40 (420- μm) and No. 30 (600- μm) Standard Testing Sieves. Material collected on the No. 40 screen was transferred to sample jars for later identification. Material from the No. 30 screen was observed at 3X power using a standard dissecting microscope to remove any remaining macroinvertebrates. All macroinvertebrates collected during the aquatic inventory were identified to the most specific taxonomic level possible considering the number of specimens collected and the condition of the specimens. The samples were vouchered in 70-percent isopropanol and later identified to species using taxonomic references that included Merritt and Cummins (1978), Pennak (1953), and Burch (1982). Voucher specimens of macroinvertebrates collected during the aquatic inventory are maintained at B&N.

2.2.3 Unionids

For purposes of the mussel (unionid) inventory and assessment of aquatic habitat areas, the study area was divided up into transects. Semiquantitative sampling was performed along transects created perpendicular to the west bank of the Ohio River. The area from RM 340.5 north to the lock and dam was divided into five transects identified as T1 through T5 which were spaced 100 meters apart. The area from the lock and dam north to RM 343 was divided into 13 more transects marked as T6 through T18 which were spaced 200 meters apart along the shoreline. These transects served as the basis for dividing up collection areas for unionids. Additional qualitative sampling was conducted in areas of unionid concentrations. Detailed information on the methodologies used to complete the unionid inventory is included in the report prepared by ESI. (Appendix B).

2.2.4 Water Quality

Indicators of water quality within different habitat types were measured in the field during the aquatic inventory. Parameters measured during the study included turbidity (secchi depth), dissolved oxygen (DO), current velocity, temperature, pH, and conductivity. Measurements were taken along the shoreline, and on average, approximately 18 meters from the bank. Measurements were taken just below

the water surface and on the bottom within each zone. Final measurements within different habitat areas were averaged to give an indication of overall water quality. Data on water depth and bottom substrates was also collected within each habitat type encountered.

2.3 Threatened and Endangered Species

Several investigations were undertaken to discern the absence, presence, or probable occurrence of T&E plant and animal species in the study area. These studies were conducted in the following order and rationale.

First, existing background ecological information was reviewed for any indication of the past, present, or probable occurrence of protected species, or their preferred habitats, in or near the study area. Secondly, information requests were forwarded to the state and federal agencies responsible for the protection and maintenance and existence of such species, requesting information they maintain regarding the existence of these species in the study area. With this information, B&N scientists visited the study area to investigate the suitability of the existing on-site habitats for the state- and federal-listed species. A habitat map was produced using AutoCAD Version 12, and habitats were quantified. Biological surveys were conducted for plants, mammals, avifauna, herpetofauna, fish, macroinvertebrates, and unionid mussels. The potential for occurrence of T&E species was estimated based on the occurrence of preferred habitat because T&E species are, by definition, difficult to locate. Based on a request by U.S. Fish and Wildlife Service (F&WS) potential Indiana Bat habitat located on the site surveyed by BHE. A copy of the report outlining details of the methodology used by BHE in the survey is included in Appendix C,

Agency sources contacted for information included ODNR, Division of Natural Areas and Preserves (DNAP) and KSNPC. Data on T&E species were also obtained from the F&WS. These agencies list T&E species status in the United States, Ohio, and Kentucky and include any state-designated special interest species.

3.0 LITERATURE REVIEW

This section contains the findings of the literature review and agency consultation that were performed prior to the site investigation.

3.1 Topography and Land Use

The study area is part of the Mountains and Eastern Coalfields physiographic region of the unglaciated Allegheny Plateau. The topography is generally level or gently rolling floodplain and terraces, with the exception of riverbank and stream ravine areas where topography is steep. Current land uses in the study area include agricultural land, paved and mowed areas and structures associated with the locks and dam, recreational areas, wooded areas associated primarily with streams, and cleared and mowed areas associated with a natural gas transmission pipeline.

3.2 Geology

The geology consists of Pennsylvanian and Mississippian Systems. The Pottsville and Allegheny Groups represent the Pennsylvanian System, and the Waverly Group represents the Mississippian System.

The bedrock consists of interbedded shale, siltstone, and sandstone with a few limestone layers in the Upper Pennsylvanian and Upper Mississippian. The most extensive bedrock in the area is the Breathitt Formation (Hail et al., 1979).

3.3 Soils

Most of the soils formed in material weathered from acid shale, sandstone, and siltstone, and minor amounts formed from calcareous shales. The soils for the study areas consist of the Elk-Huntington-Otwell Association. This association consists of deep, well-drained and moderately well-drained, nearly level soils on terraces and floodplains.

Huntington series soils occupy the river floodplain in the study area and are deep, well-drained alluvial soils formed from mixed materials of shale, sandstone, and limestone origin. Permeability is moderate. The surface layer is very dark grayish brown silt loam about 11 inches thick. The subsoil from

11 to 64 inches is dark grayish brown and dark brown silt loam. Bedrock is found at depths of 40 to 84 inches or greater.

Elk series soils are a deep, well-drained soils found on stream terraces. The surface layer is dark brown silt loam about 9 inches thick. The subsoil, about 36 inches thick, is dark brown or brown silt loam or light silty clay loam. The substratum to a depth of 73 inches is dark yellowish brown or dark brown stratified sandy loam and loam. Permeability is moderate.

Otwell series soils are a deep, moderately well-drained, nearly level and gently sloping soils that have a fragipan. Otwell soils formed in alluvium deposited by the Ohio River. These nearly level soils are found on low ridges that are roughly parallel to the Ohio River. The surface layer is dark brown silt loam about 7 inches thick. The upper part of the subsoil is brown and yellowish-brown, friable silt loam that extends to a depth of about 26 inches. The lower part of the subsoil is a firm, brittle, and compact fragipan with redox featured silt loam that extends to a depth of about 40 inches. The fragipan rests on a firm substratum of brown, silt loam with redox features that extends to a depth of 60 inches or more. Permeability is moderate above the fragipan and is slow in the pan (Hail et al., 1979).

3.4 Present Land Use Practices

The study area lies within the Western Allegheny Plateau ecoregion as described by Omerink and Gallant (1988). An ecoregion is an area that contains relatively homogeneous land use, potential natural vegetation, land surface form, and soils (Omerink, 1987). The Western Allegheny Plateau ecoregion land use is limited by poor soils, steep topography, and high erosion hazard. Thus, most of the area is forested, and timber harvest is important. A large portion has been strip-mined for coal. Less than 20 percent is cropland, which occurs in valley floors usually in alfalfa and small grains for beef and dairy cattle. Fruit and vegetables are found on a local scale. Urban growth continually infringes on forested areas.

3.5 Terrestrial Resources

3.5.1 Historical Terrestrial Resources

Prior to development, the study area was completely forested. The Unglaciated Allegheny Plateau is within the limits of the historical Mixed Mesophytic Forest community. Extensive tracts of an elm-ash-maple-type (American elm [*Ulmus americana*], black ash [*Fraxinus nigra*], white ash [*Fraxinus*

americana], and red maple [*Acer rubrum*]) occurred in depressions and bottomland portions of the study area (Braun, 1947).

European settlers exacted great changes on the landscape in the mid-to-late 1800s. These changes continued into the 1940s when the study area resembled existing vegetative conditions (Lamb, 1979). Human activities in the study area have altered the natural environment primarily through agriculture and urbanization. Approximately 90 percent of the area has been modified to forestry, agriculture, lawns, buildings, and other development. The remaining forest areas are dissected and located on gently sloping to very steep areas found along the river corridors. These forest areas provide riparian habitat; however, because of human development and pollution, they do not currently provide the high quality habitats of the past.

3.5.2 Recent Terrestrial Survey Results

Due to recent changes in the study area caused by agricultural activities, only the most recent studies regarding terrestrial ecology are applicable. The most recent study is an unpublished report prepared by COE biologists for the study area in 1998. The study included an inventory of terrestrial species for the study area. A complete copy of the report is provided in Appendix D.

3.6 Aquatic Resources

The Aquatic Resources section describes the historical and current conditions of the only major aquatic resource in the study area, the Ohio River.

3.6.1 Historical Aquatic Resources

Prior to the 1750s, the Ohio River was dominated by fish, molluscan, and invertebrate communities that preferred clean, clear water and silt-free, coarse substrates (Trautman, 1981). The abundance of forests, wetlands, and natural vegetation that maintained these high-quality river and stream conditions slowly gave way to agricultural interests as farming practices became more widespread and mechanized. Farming interests cleared forests, drained fields and wetlands, dredged, cleared, and channelized streams in order to increase the arable acreage of the land. The practices had significant impact on the hydrologic conditions of the state, resulting in a lower water table, lower stream flows, and an increase in erosion of sediments from farmed lands. The subsequent increase in erosion caused

elevated levels of suspended solids in streams and the silting over of the clay-free substrates. As a result of these perturbations, the fish and molluscan communities have since been modified from communities requiring clean water and substrates to communities tolerant of turbid waters and fine substrates. The increase in the human population and the industrialization of the early 1900s increased the organic and inorganic pollution inputs to the streams and rivers in the study area (Trautman, 1981).

The construction and subsequent upgrade of wastewater treatment plants to meet Clean Water Act (CWA) regulations and a decrease in industrial effluent per the National Pollutant Discharge Elimination System has begun, and continues, to allow improvement of water quality and habitat quality of the Ohio River (Trautman, 1981).

3.6.2 Recent Aquatic Survey Results

Many of the streams within the Western Allegheny Plateau ecoregion are channelized, but the higher quality streams still have some wooded riparian vegetation. The Ohio River is classified as Warmwater Habitat by the Ohio EPA (1993). The warmwater habitat designation is applied to waters capable of supporting and maintaining a balanced, integrated, adaptive community of warmwater aquatic organisms having a species composition, diversity, and functional organization comparable to the 25th percentile of the identified reference sites within their respective ecoregion.

Currently, the Ohio River Valley Water Sanitation Commission (ORSANCO) is conducting ongoing aquatic sampling on the Ohio River, including the study area. The most recent information provided by ORSANCO is included in Appendix E.

3.7 Threatened and Endangered Species

Under Section 7 consultation, the U.S. F&WS provided a list of federally listed T&E species found in the states of Ohio and Kentucky. The list shows counties of current, recent (25 years), and possible distributions. The study area is within the range of the following species; however, there has been no confirmation of their presence within the study area. In addition, there is no documented occurrence of critical habitat within the study area for any federally listed T&E species.

- The Indiana Bat is a state and federal endangered species that has a possible distribution in Greenup County. Caves and caverns are the preferred winter habitat and are utilized for hibernating (Gottschang, 1981). Dead trees and snags along riparian corridors—especially those with exfoliating bark (e.g., shagbark hickory)—may be used by the Indiana bat as maternity roost areas. Stream corridors and nearby woodlots may be used as forage areas.
- Federally endangered mussel species possibly occurring in the vicinity of Greenup Locks and Dam and found recently in upper Ohio River as documented by U.S. F&WS are as follows:
 - Fanshell (*Cyprogenia stegaria*)
 - Pink mucket (*Lampsilis abrupta*)
 - Tuberclined blossom (*Epioblasma t. torulosa*)
 - Ring pink (*Obovaria retusa*)
 - White wartyback (*Plethobasus cicatricosus*)
 - Orange-foot pimpleback (*Plethobasus cooperianus*)
 - Clubshell (*Pleurobema clava*)
 - Rough pigtoe (*Pleurobema plenum*)

Because mussels are suspension feeders, their preferred habitat includes areas with relatively good water quality including significant current velocities and low siltation. In riverine systems, the best mussel habitat can usually be found in areas of heterogeneous substrates consisting of less coarse sediments near river banks as opposed to channel areas. Specifically, unionid beds are most typically located in areas characterized by a mixture of stable sand, gravel, and cobble substrates. Depositional areas are usually lacking in any significant mussel communities based on the constantly shifting and changing nature of these zones.

The ODNR/DNAP and KSNPC were contacted to review their Natural Heritage maps and files for reported occurrences of rare, special interest, threatened, and endangered species in the vicinity of the study area.

ODNR/DNAP reported the following plant species occurrences in the vicinity of the study area (Table 1). Both occurrences are approximately at the foot of the aerial gas pipeline crossing on the Ohio side.

Table 1. Ohio Heritage Program, terrestrial species with reported occurrences.

| Scientific Name | Common Name | Status |
|----------------------------|--------------------|------------------------|
| <i>Paspalum fliuitans</i> | riverbank paspalum | Potentially threatened |
| <i>Descurainia pinnata</i> | tansy mustard | Threatened |

KSNPC reported the following plant species occurrences in the vicinity of the study area (Table 2). The single report was from the junction of the C&O Railroad track and the natural gas pipeline near Gray's Branch, just west of the study area boundary.

Table 2. Kentucky Heritage Program, terrestrial species with reported occurrences.

| Scientific Name | Common Name | Status |
|---------------------------|-----------------|-----------------|
| <i>Sida hermaphrodita</i> | Virginia mallow | Special concern |

None of the above-referenced species were encountered during the terrestrial inventory conducted by B&N in the vicinity of Greenup Locks and Dam.

The ODNR/DNAP was contacted to review their Natural Heritage maps and files for the vicinity of Greenup Locks and Dam located on the Wheelersburg USGS 7.5-minute quadrangle for Scioto County, Ohio. Records from ODNR/DNAP for aquatic species with a special status in Ohio occurring in the vicinity of the site are shown in Table 3.

Table 3. Ohio Heritage Program, aquatic species with reported occurrences.

| Scientific Name | Common Name | Status |
|--------------------------------|----------------|-----------------------|
| <i>Lepisosteus platostomus</i> | Shortnose Gar | Ohio Endangered |
| <i>Esox masquinongy</i> | Muskellunge | Ohio Special Interest |
| <i>Ichthyomyzon unicuspis</i> | Silver Lamprey | Ohio Threatened |
| <i>Hiodon alosoides</i> | Goldeye | Ohio Endangered |
| <i>Moxostoma carinatum</i> | River Redhorse | Ohio Special Interest |
| <i>Hiodon tergisus</i> | Mooneye | Ohio Special Interest |

None of the above-referenced species were encountered during the aquatic inventory conducted by B&N in the vicinity of Greenup Locks and Dam.

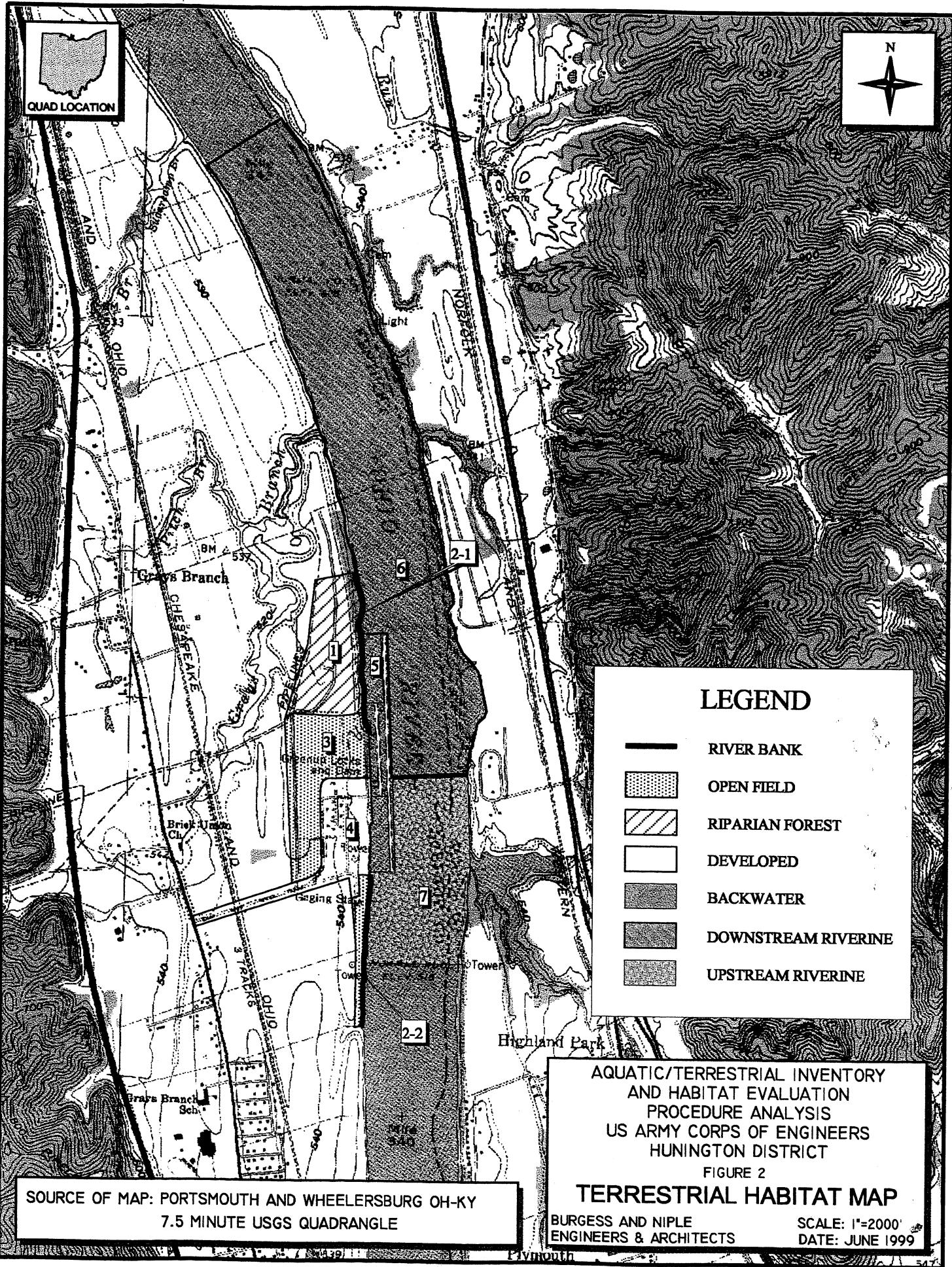
The KSNPC was also contacted for any information on potential threatened or endangered species which may have been reported for the study area. The Natural Heritage Program Database was reviewed to determine if any of the endangered, threatened, or special-concern plants and animals or

exemplary natural communities monitored by KSNPC had a record of occurrence within the vicinity of Greenup Locks and Dam. The agency reported three occurrences of aquatic animals within the specified area as shown in Table 4.

Table 4. Kentucky Heritage Program, aquatic species with reported occurrences.

| Scientific Name | Common Name | Status |
|-------------------------------|----------------|--|
| <i>Obovaria retusa</i> | Ring Pink | Kentucky Endangered and Federally Endangered |
| <i>Pleurobema pyramidatum</i> | Pyramid Pigtoe | Kentucky Endangered |
| <i>Percopsis omiscomaycus</i> | Trout-Perch | Kentucky Special Concern |

The ring pink and pyramid pigtoe were last observed or collected from the vicinity of the site in 1929. Both specimens were found in the Ohio River at the mouth of Ginat Creek upstream of the study area. The trout-perch was last observed in 1905 in the Greenup Pool area of the Ohio River.



4.0 RESULTS

The Results section discusses the findings of the terrestrial and aquatic field surveys. Lists of terrestrial and aquatic species and their habitats are located in Tables 5 through 9. Water quality results obtained during the aquatic survey are summarized in Table 10. Photographs of the referenced habitats are provided in Appendix F.

4.1 Terrestrial Ecology

Four principal habitat types were identified in the study area: open field, riparian forest, and river bank habitat. Mowed, paved areas, and agricultural fields were not considered as viable habitat types and were excluded from the survey. A map showing the distribution of the four principal terrestrial habitat types is provided on Figure 2. Habitat types are described below.

Open Field – Open field areas occurred in the vicinity of the locks and dam and gas transmission pipeline easement. These areas generally lack woody vegetation and are dominated by unmowed pasture grasses and meadow species. Total acreage in this habitat type within the study area is approximately 83 acres.

Riparian Forest – This habitat type consists of approximately 47 acres located between the maintained areas around the locks and dam and the aerial gas transmission pipeline crossing to the north. The tree canopy was relatively open (40-percent canopy closure), and the area is dissected by several dirt roads and trails. Understory growth is generally dense throughout. Average canopy height is approximately 30 feet. Estimated age of canopy trees was 15 to 20 years. Dominant canopy species include cottonwood (*Populus deltoides*), box elder (*Acer negundo*), silver maple (*Acer saccharinum*), and sycamore (*Platanus occidentalis*). Black locust, (*Robinia pseudoacacia*), black cherry (*Prunus serotina*), American elm (*Ulmus americana*), and box elder are dominant tree species in the understory.

River Bank – This habitat type occupies virtually the entire length of the river shoreline within the study area, and is characterized by sparse vegetation and intermittently exposed sand beaches and mud flats. At the time of the inventory, the area was colonized primarily by willows (*Salix* spp.) and pioneer herbaceous species, including field horsetail (*Equisetum arvense*), lamb's quarters (*Chenopodium album*), beggar's tick (*Bidens frondosa*), swamp smartweed (*Polygonum coccineum*) and cottonwood (*Populus deltoides*) seedlings. Mammal and bird tracks and other signs were prevalent in this area indicating its importance as a pivotal corridor used by many animal species. Total estimated acreage in this type of habitat is approximately 9 acres.

4.1.1 Terrestrial Inventory Species Lists

Tables 5 and 6 below list the terrestrial animal and plant species observed within the study area. Species are listed alphabetically by Scientific name.

Table 5. Terrestrial animal species, May 1999.

| BIRDS | | |
|-------------------------------|---------------------------|----------------------------|
| Scientific Name | Common Name | Habitat |
| <i>Agelaius phoeniceus</i> | Redwing Blackbird | Open Field |
| <i>Anas platyrhynchos</i> | Mallard Duck | Riparian Forest |
| <i>Archilochus colubris</i> | Ruby-Throated Hummingbird | Riparian Forest/River Bank |
| <i>Bombycilla cedrorum</i> | Cedar Waxwing | Riparian Forest |
| <i>Branta canadensis</i> | Canada Goose | River Bank/open Field |
| <i>Buteo jamaicensis</i> | Red-Tailed Hawk | Open Field |
| <i>Butorides striatus</i> | Green Heron | Riparian Forest |
| <i>Cardinalis cardinalis</i> | Cardinal | Riparian Forest |
| <i>Cathartes aura</i> | Turkey Buzzard | Open Field |
| <i>Charadrius vociferous</i> | Killdeer | Open Field |
| <i>Colaptes auratus</i> | Yellow-Shafted Flicker | Open Field |
| <i>Corvus brachyrhynchos</i> | Common Crow | River Bank |
| <i>Cyanocitta cristata</i> | Blue Jay | Riparian Forest |
| <i>Dryocopus pileatus</i> | Pileated Woodpecker | Riparian Forest |
| <i>Dumatella carolinensis</i> | Catbird | Riparian Forest |
| <i>Fulica americana</i> | American Coot | River Bank |
| <i>Geothlypis trichas</i> | Common Yellowthroat | Riparian Forest |
| <i>Hirundo rustica</i> | Barn Swallow | Open Field |
| <i>Hylocichla mustelina</i> | Wood Thrush | Riparian Forest |
| <i>Icterus galbula</i> | Baltimore Oriole | Open Field |
| <i>Parus bicolor</i> | Tufted Titmouse | Riparian Forest |
| <i>Passerina cyanea</i> | Indigo Bunting | Riparian Forest |
| <i>Phalacrocorax auritus</i> | Double Crested Cormorant | River Bank |

| BIRDS (Continued) | | |
|------------------------------------|---------------------|-----------------|
| Scientific Name | Common Name | Habitat |
| <i>Picoides villosus</i> | Hairy Woodpecker | Riparian Forest |
| <i>Pipilo erythrorthalmus</i> | Rufous-Sided Towhee | Riparian Forest |
| <i>Progne subis</i> | Purple Martin | Open Field |
| <i>Quiscalus quiscula</i> | Common Grackle | Riparian Forest |
| <i>Setophaga ruticilla</i> | Redstart | Riparian Forest |
| <i>Sialia sialis</i> | Eastern Bluebird | Open Field |
| <i>Sturnella magna</i> | Eastern Meadow Lark | Open Field |
| <i>Sturnus vulgaris</i> | Starling | Open Field |
| <i>Thryothorus ludovicianus</i> | Carolina Wren | Riparian Forest |
| <i>Toxostoma rufum</i> | Brown Thrasher | Woods |
| <i>Turdus migratorius</i> | American Robin | Riparian Forest |
| <i>Vireo olivaceus</i> | Red-Eyed Vireo | Riparian Forest |
| <i>Zenaida macroura</i> | Mourning Dove | Open Field |
| Total No. Bird Species = 39 | | |

| MAMMALS | | |
|--------------------------------------|-----------------------|----------------------------|
| Scientific Name | Common Name | Habitat |
| <i>Blarina brevicauda</i> | short-tailed shrew | Open Field |
| <i>Castor canadensis</i> | beaver | River Bank |
| <i>Didelphis virginiana</i> | possum | Riparian Forest |
| <i>Eptesicus fuscus</i> | big brown bat | Riparian Forest |
| <i>Marmota monax</i> | woodchuck | Open Field |
| <i>Microtus pennsylvanicus</i> | meadow vole | Open Field |
| <i>Odocoileus virginianus</i> | whitetail deer | Riparian Forest |
| <i>Peromyscus maniculatus</i> | deer mouse | Riparian Forest |
| <i>Procyon lotor</i> | raccoon | Riparian Forest/River Bank |
| <i>Reithrodontomys humulis</i> | Eastern harvest mouse | Open Field |
| <i>Tamias striatus</i> | Eastern chipmunk | Riparian Forest |
| <i>Vulpes vulpes</i> | red fox | River Bank |
| Total No. Mammal Species = 12 | | |

| REPTILES/AMPHIBIANS | | |
|--|------------------------|-----------------|
| Scientific Name | Common Name | Habitat |
| <i>Chrysemys picta picta</i> | Eastern painted turtle | River Bank |
| <i>Terrapene carolina carolina</i> | Eastern box turtle | Riparian Forest |
| Total No. Reptile/Amphibian Spp = 2 | | |

Table 6. Terrestrial plant species, May 1999.

| PLANTS | | |
|---------------------------------|---------------------------|----------------------------|
| Scientific Name | Common Name | Habitat |
| <i>Acer negundo</i> | box elder | Riparian Forest |
| <i>Acer saccharinum</i> | silver maple | Riparian Forest |
| <i>Actinomerus alternifolia</i> | wingstem | Riparian Forest |
| <i>Agrostis alba</i> | redtop grass | Open Field |
| <i>Allium canadense</i> | wild garlic | Riparian Forest |
| <i>Amorpha fruticosa</i> | false indigo | Open Field |
| <i>Arctium minus</i> | burdock | Open Field |
| <i>Asclepias syriaca</i> | milkweed | Open Field |
| <i>Barbarea vulgaris</i> | yellow rocket | Open Field |
| <i>Bidens frondosa</i> | beggars tick | Open Field/River Bank |
| <i>Boehmeria cylindrica</i> | false nettle | Riparian Forest |
| <i>Bromus tectorum</i> | brome grass | Open Field |
| <i>Campsis radicans</i> | trumpet creeper | Riparian Forest |
| <i>Capsella bursa-pastoris</i> | shepherds purse | Open Field |
| <i>Carex intumescens</i> | bladder sedge | Riparian Forest |
| <i>Carya cordiformis</i> | bitternut hickory | Riparian Forest |
| <i>Carya laciniosa</i> | shellbark hickory | Riparian Forest |
| <i>Chenopodium album</i> | lambs quarters | River Bank |
| <i>Convolvulus arvensis</i> | field bindweed | Open Field |
| <i>Dactylis glomerata</i> | orchard grass | Open Field |
| <i>Equisetum arvense</i> | field horsetail | River Bank |
| <i>Erigeron annuus</i> | daisy fleabane | Open Field |
| <i>Fraxinus pennsylvanica</i> | green ash | Riparian Forest |
| <i>Galium aparine</i> | cleavers | Riparian Forest |
| <i>Geranium pusillum</i> | small-flowered cranesbill | Open Field |
| <i>Glechoma herderacea</i> | ground ivy | Riparian Forest |
| <i>Impatiens capensis</i> | jewelweed | Riparian Forest |
| <i>Juglans nigra</i> | black walnut | Riparian Forest |
| <i>Lamium purpurea</i> | purple deadnettle | Open Field |
| <i>Lolium multiflorum</i> | Italian ryegrass | Open Field |
| <i>Lonicera japonica</i> | Japanese honeysuckle | Riparian Forest |
| <i>Medicago lupulina</i> | black medic | Open Field |
| <i>Ornithogalum umbellatum</i> | star of Bethlehem | Riparian Forest/Open Field |
| <i>Osmorrhiza claytoni</i> | sweet cicely | Riparian Forest |
| <i>Panicum clandestinum</i> | deer tongue grass | Riparian Forest/Open Field |
| <i>Phytolacca americana</i> | pokeweed | Riparian Forest |
| <i>Plantain major</i> | common plantain | Open Field |
| <i>Platanus occidentalis</i> | sycamore | Riparian Forest |
| <i>Polygonatum biflorum</i> | smooth Solomons seal | Riparian Forest |
| <i>Polygonum coccineum</i> | swamp smartweed | River Bank |

| PLANTS (Continued) | | |
|-------------------------------------|--------------------|----------------------------|
| Scientific Name | Common Name | Habitat |
| <i>Quercus muehlenbergii</i> | chinkapin oak | Riparian Forest |
| <i>Rhus typhina</i> | staghorn sumac | Riparian Forest |
| <i>Robinia pseudoacacia</i> | black locust | Riparian Forest/Open Field |
| <i>Rosa multiflora</i> | multiflora rose | Riparian Forest |
| <i>Rubus</i> spp. | blackberry | Riparian Forest/Open Field |
| <i>Rumex crispus</i> | curly dock | Open Field |
| <i>Salix interior</i> | sandbar willow | River Bank |
| <i>Salix nigra</i> | black willow | River Bank |
| <i>Sambucus canadensis</i> | common elder | Riparian Forest |
| <i>Solidago</i> spp. | goldenrod | Open Field |
| <i>Stellaria media</i> | common chickweed | Open Field |
| <i>Taraxacum officinale</i> | dandelion | Open Field |
| <i>Thalictrum polygamum</i> | tall meadow rue | Riparian Forest |
| <i>Thlaspi arvense</i> | penny cress | Open Field |
| <i>Toxicodendron radicans</i> | poison ivy | Riparian Forest/Open Field |
| <i>Tragopogon pratensis</i> | yellow goatsbeard | Open Field |
| <i>Trautvetteria carolinensis</i> | tassel rue | Riparian Forest |
| <i>Trifolium pratense</i> | red clover | Open Field |
| <i>Ulmus americana</i> | American elm | Riparian Forest |
| <i>Urtica dioica</i> | stinging nettle | Riparian Forest |
| <i>Valerianella olitoria</i> | lamb's lettuce | Open Field |
| <i>Vicia cracca</i> | bird vetch | Open Field |
| <i>Vitis</i> spp. | grape | Riparian Forest |
| Total No. Plant Species = 68 | | |

4.2 Aquatic Ecology

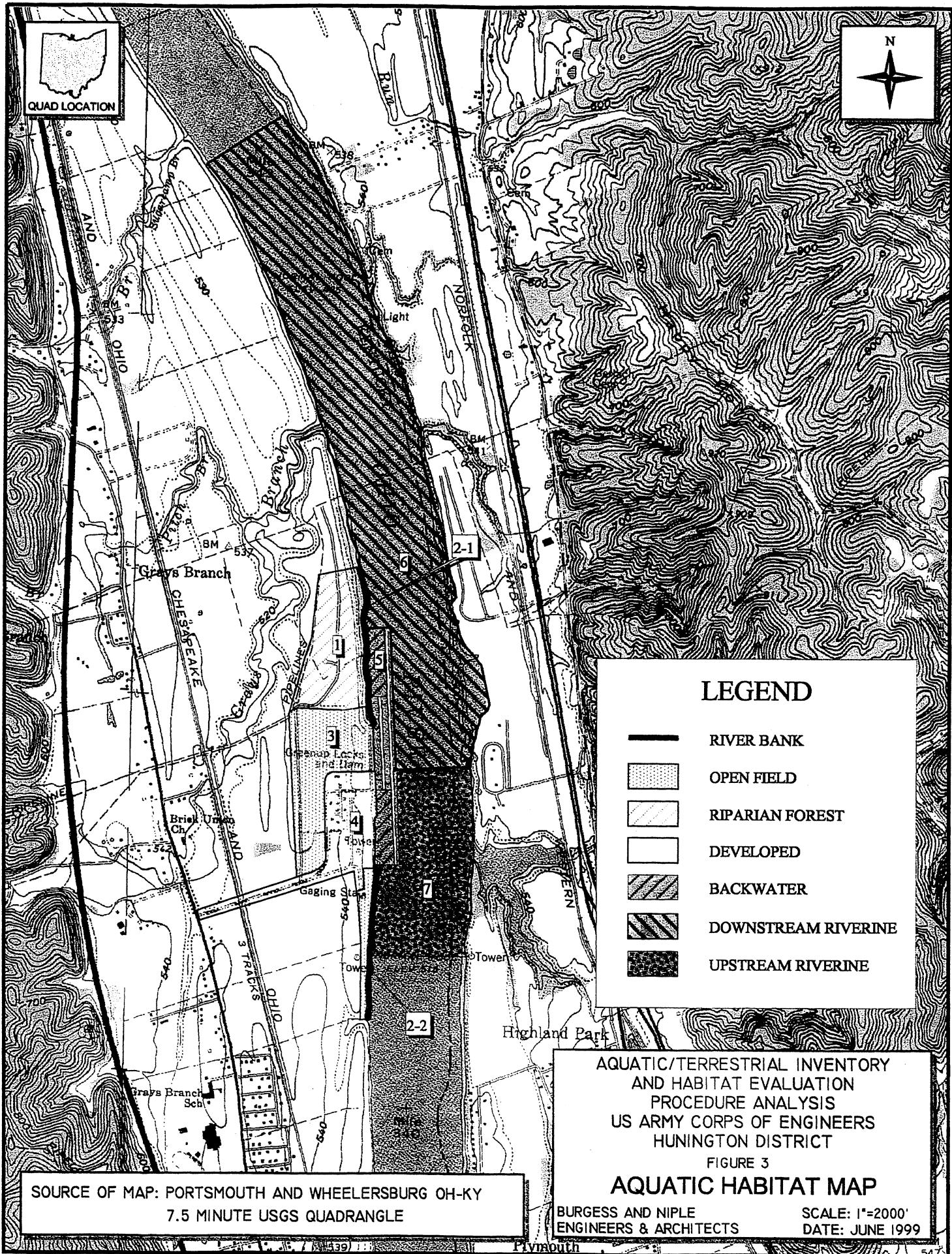
Three different habitats were encountered during the aquatic inventory conducted at Greenup Locks and Dam. These areas include two riverine zones and a simulated backwater (pool) area created by the lock structures. Aquatic habitat areas are shown on the Habitat Aquatic Map (Figure 3) with photographs included in Appendix F, and voucher specimen photographs are provided in Appendix G.

4.2.1 Aquatic Habitats and Fish Communities

Upstream Riverine – The upstream portion of the study area, starting at RM 340.5 and ending at the upstream limit of the lock structures, is approximately 400 meters in length and spans the area from T1 through T5. This area is characterized primarily by sand and silt substrate types with some debris. The shoreline within this zone consists of a vegetated bank with a steep slope down to the edge of the river. The riparian zone along this stretch of the river is characterized by woody debris, undercut banks, root wads, root mats, and overhanging vegetation. Water depths within this area range from two to five feet along the shore to 10 to 20 feet approximately six meters from the bank. Juvenile *Pyłodictis olivaris* (flathead catfish) were collected along the vegetated shoreline. This was the only vertebrate species collected from this habitat area. Total areal extent of the Upstream Riverine habitat is 40 acres.

Downstream Riverine – The second habitat area observed during the aquatic inventory was a backwater (pool) area located around RM 341.0, spanning the area just north of T5 and just south of T6 to the lock facilities. This area is approximately 1,000 meters in length and has been created by the presence of the lock structures along the west shore of the Ohio River. This habitat is characterized by sand and silt substrate types, with a predominance of silt in these areas. The shoreline just north of T5 consists of a bank area with riprap and a vegetated shoreline around the lock facilities. Another area with similar habitat characteristics is located on the north side of the dam, just west of the lock wall and south of T6. Water depths within these areas were found to be five feet and less. Vertebrate species collected from this habitat included *Lepomis gibbosus* (pumpkinseed sunfish), *Lepomis megalotis* (longear sunfish), *Lepomis macrochirus* (bluegill), *Notropis atherinoides* (emerald shiner), *Hybopsis storriiana* (silver chub), and *Pimephales notatus* (bluntnose minnow). These species were primarily collected close to the shoreline among overhanging vegetation. Other species collected from deeper water in this area included *Micropterus salmoides* (largemouth bass), *Carpiodes carpio* (river carpsucker), *Carpiodes cyprinus* (quillback carpsucker), *Carpiodes velifer* (highfin carpsucker), *Ictalurus punctatus* (channel catfish), *Aplodinotus grunniens* (freshwater drum), *Minytrema melanops* (spotted sucker), *Ictiobus bubalus* (smallmouth buffalofish), *Alosa chrysochloris* (skipjack herring), and *Lepisosteus osseus* (longnose gar).

Total estimated areal extent of the Downstream Riverine Habitat is 210 acres.



Backwater – The last habitat area observed originates around RM 341.5 and extends to RM 343.0 downstream of the locks and dam. This zone is approximately 2,400 meters in length, spanning the area from T6 to T18. Substrates within this zone consist of various mixtures of clay, cobble, silt, sand, and gravel. Cobble substrates appeared to dominate in the vicinity of RM 342.0 to 343.0. The shoreline within this zone is characterized by areas of cobble and sand, with evidence of past placement of dredge material along the shoreline. Water depths within this habitat area range from five to eight feet along the shoreline dropping to around 11 feet approximately six meters from the shore. Species collected from this habitat area included *Moxostoma anisurum* (silver redhorse), *Moxostoma erythrurum* (golden redhorse), *Moxostoma duquesnei* (black redhorse), *Ambloplites rupestris* (rock bass), *Carpoides carpio* (river carpsucker), *Lepisosteus osseus* (longnose gar), *Lepomis macrochirus* (bluegill), *Micropterus punctulatus* (spotted bass), and *Morone chrysops* (white bass). These species were primarily collected from the deeper areas with rock bass and bluegill being collected around submerged structures or vegetation. *Notropis atherinoides* (emerald shiner), *Notropis spilopterus* (spotfin shiner), *Notropis stramineus* (sand shiner), *Notropis blennius* (river shiner), and *Notropis hudsonius* (spottail shiner) were primarily collected along the shoreline in shallow water.

Total estimated aerial extent of the Backwater Habitat is 23 acres.

Dorosoma cepedianum (gizzard shad) was collected throughout the range of the aquatic inventory from RM 340.5 to RM 343.0 and was concluded to be one of the most abundant vertebrate species present in the study area. In addition, a striped bass hybrid was also collected primarily in the vicinity of RM 342 to RM 343.

4.2.2 Macroinvertebrates

Dominant macroinvertebrates collected during the aquatic inventory included *Dreissena polymorpha* (zebra mussel), *Corbicula fluminea* (Asian clam), *Lumbriculus variegatus* (aquatic oligochaete), *Branchiura sowerbyi* (aquatic oligochaete), and *Pristina breviseta* (aquatic oligochaete). These species were collected within all habitats encountered between RM 340.5 and RM 343.0. *Hexagenia* sp. (burrowing mayfly) and *Gammarus fasciatus* (amphipod) were collected primarily from the sand/silt substrates of the area spanning T1 through T6 (approximately RM 340.5 to RM 341.5). Members of the Order Diptera, Family Chironomidae (midges) were also collected from all habitat areas

between RM 340.5 and RM 343.0. Macroinvertebrate species identified between RM 340.5 and RM 343.0 are considered to be representative of species typically occurring in large river systems. The number of species collected is primarily a function of the substrate and water conditions of the riverine zone sampled during the aquatic inventory.

4.2.3 Unionids

No unionids were found upstream of the dam or downstream to approximately RM 342.0. A narrow zone of unionids was found within 50 meters of the Kentucky bank between RM 342.0 and RM 343.0. A total of 1,230 live unionids and 18 live species was found. In all, 24 species of unionid mussels were collected during the aquatic inventory. Several live species listed as endangered in Ohio were also collected. These species include *Ellipsaria lineolata* (Elephant ear), *Lampsilis ovata* (Pocketbook), *Magalonaias nervosa* (Washboard), *Plethobasus cyphyus* (Sheepnose), *Pleurobema cordatum* (Ohio pigtoe), and *Quadrula nodulata* (Wartyback). No federally endangered species were collected live, but *Lampsilis ovata* (pocketbook), a Kentucky endangered species, and *Plethobasus cyphyus* (sheepnose), a special concern species in Kentucky, were both collected. In addition, *Obovaria retusa* (ring pink) was collected as a subfossil shell. This species is listed as endangered within the State of Kentucky and also by the U.S. F&WS. Further discussion of these three mussel species is provided in Section 4.3, Threatened and Endangered Species.

4.2.4 Aquatic Species Inventory Lists

A list of the species collected during the aquatic inventory conducted at Greenup Locks and Dam is presented below. Species have been divided into vertebrates (fish) (Table 7), macroinvertebrates (Table 8), and unionid mussels (Table 9).

Table 7. Fish species, May 1999.

| Scientific Name | Common Name |
|------------------------------------|----------------------------------|
| | |
| <i>Dorosoma cepedianum</i> | Eastern Gizzard Shad |
| <i>Notropis atherinoides</i> | Common Emerald Shiner |
| <i>Morone chrysops</i> | White Bass |
| <i>Lepomis megalotis</i> | Central Longear Sunfish |
| <i>Micropterus salmoides</i> | Northern Largemouth Blackbass |
| <i>Pylodictis olivaris</i> | Flathead Catfish ⁽¹⁾ |
| <i>Lepomis macrochirus</i> | Northern Bluegill Sunfish |
| <i>Lepomis gibbosus</i> | Pumpkinseed Sunfish |
| <i>Lepisosteus osseus</i> | Longnose Gar |
| <i>Alosa chrysochloris</i> | Skipjack Herring |
| <i>Carpoides carpio</i> | Northern River Carpsucker |
| <i>Ambloplites rupestris</i> | Northern Rockbass ⁽²⁾ |
| <i>Moxostoma duquesnei</i> | Black Redhorse |
| <i>Hybopsis storeriana</i> | Silver Chub |
| <i>Notropis spilopterus</i> | Spotfin Shiner |
| <i>Notropis stramineus</i> | Sand Shiner |
| <i>Notropis blennius</i> | River Shiner |
| <i>Pimephales notatus</i> | Bluntnose Minnow |
| <i>Moxostoma erythrurum</i> | Golden Redhorse |
| <i>Moxostoma anisurum</i> | Silver Redhorse |
| <i>Carpoides cyprinus</i> | Central Quillback Carpsucker |
| <i>Ictalurus punctatus</i> | Channel Catfish |
| <i>Notropis hudsonius</i> | Spottail Shiner |
| <i>Micropterus punctulatus</i> | Northern Spotted Blackbass |
| <i>Carpoides velifer</i> | Highfin Carpsucker |
| <i>Dorosoma petenense</i> | Threadfin Shad |
| <i>Ictiobus bubalus</i> | Smallmouth Buffalofish |
| <i>Minytrema melanops</i> | Spotted Sucker |
| <i>Aplodinotus grunniens</i> | Freshwater Drum |
| Total No. Fish Species = 29 | |

(1) Juvenile

(2) Single individual

***Striped Bass Hybrid was also collected.

Table 8. Macroinvertebrates species, May 1999.

| Order | Family | Subfamily | Genus | Species | Common Name |
|--|--------------|----------------|------------------------|-------------------|---------------------------|
| Veneroida | Dreissenidae | - | <i>Dreissena</i> | <i>polymorpha</i> | Zebra Mussel |
| Veneroida | Corbiculidae | - | <i>Corbicula</i> | <i>fluminea</i> | Asian Clam |
| Mesogastropoda | Hydrobiidae* | - | - | - | Gastropod |
| Anostraca* | - | - | - | - | Branchiopod Crustacean |
| Lumbriculida | - | - | <i>Lumbriculus</i> | <i>variegatus</i> | Oligochaete |
| Tubificida | Tubificidae | - | <i>Branchiura</i> | <i>sowerbyi</i> | Oligochaete |
| Ephemeroptera | Ephemeridae | - | <i>Hexagenia</i> | sp. | Mayfly |
| Basommatophora | Ancylidae | - | <i>Ferrissia</i> | <i>rivularis*</i> | Limpet |
| Amphipoda | Gammaridae | - | <i>Gammarus</i> | <i>fasciatus</i> | Amphipod |
| Tubificida | Naididae | - | <i>Pristina</i> | <i>breviseta</i> | Oligochaete |
| Diptera | Chironomidae | Tanypodinae | <i>Ablabesmyia</i> | sp. | Midge |
| Diptera | Chironomidae | Chironominae | <i>Tanytarsus</i> | sp. | Midge |
| Diptera | Chironomidae | Chironominae | <i>Dicrotendipes</i> | sp. | Midge |
| Diptera | Chironomidae | Tanypodinae | <i>Thienemannimyia</i> | group sp. | Midge |
| Diptera | Chironomidae | Chironominae | <i>Paratanytarsus</i> | sp. | Midge |
| Diptera | Chironomidae | Tanypodinae | <i>Macropelopia</i> | sp. | Midge |
| Diptera | Chironomidae | Chironominae | <i>Polypedilum</i> | sp. | Midge |
| Diptera | Chironomidae | Chironominae | <i>Parachironomus</i> | sp. | Midge |
| Diptera | Chironomidae | Orthocladiinae | <i>Eukiefferiella</i> | sp. | Midge |
| Diptera | Chironomidae | Orthocladiinae | <i>Cricotopus</i> | sp. | Midge |
| Total No. Macroinvertebrate Taxa = 20 | | | | | |

*Single individual.

Table 9. Mussel species, May 1999.

| Scientific Name | Common Name |
|--------------------------------------|-------------------------|
| <i>Actinonaias ligamentina</i> | Mucket |
| <i>Amblema p. plicata</i> | Threeridge |
| <i>Ellipsaria lineolata</i> | Butterfly |
| <i>Elliptio crassidens</i> | Elephant Ear |
| <i>Elliptio dilatata</i> | Spike |
| <i>Fusconaia ebena</i> | Ebonyshell |
| <i>Fusconaia flava</i> | Wabash Pigtoe |
| <i>Lampsilis cardium</i> | Plain Pocketbook |
| <i>Lampsilis ovata</i> | Sharp-Ridged Pocketbook |
| <i>Lampsilis siliquoidea</i> | Fatmucket |
| <i>Leptodea fragilis</i> | Fragile Papershell |
| <i>Ligumia recta</i> | Black Sandshell |
| <i>Megalonaia nervosa</i> | Washboard |
| <i>Obliquaria reflexa</i> | Threehorn Wartyback |
| <i>Obovaria retusa*</i> | Ring Pink |
| <i>Plethobasus cyphyus</i> | Sheepnose |
| <i>Pleurobema cordatum</i> | Ohio Pigtoe |
| <i>Potamilus alatus</i> | Pink Heelsplitter |
| <i>Quadrula metanevra</i> | Monkeyface |
| <i>Quadrula nodulata</i> | Wartyback |
| <i>Quadrula p. pustulosa</i> | Pimpleback |
| <i>Quadrula quadrula</i> | Mapleleaf |
| <i>Truncilla donaciformis</i> | Fawnsfoot |
| <i>Truncilla truncata</i> | Deertoe |
| Total No. Mussel Species = 24 | |

*Collected as a subfossil shell.

4.2.5 Water Quality

Several parameters including turbidity, DO, current velocity, temperature, conductivity, and pH were measured within different habitat areas to give some idea of water quality within the study area. Measurements were taken at different depths and distances from the shoreline to give an indicator of average water quality conditions within each different habitat. Averages of these parameters are presented in Table 10 below.

Table 10. Average water quality conditions, aquatic habitat areas.

| Water Quality Parameters | RM 340.5 (T1-T5) | Backwater (T5 & T6) | RM 341.5 (T7-T18) |
|----------------------------|---------------------|------------------------|----------------------|
| Temperature (°C) | 22 | 21.5 | 22 |
| Dissolved Oxygen (DO mg/l) | 7.6 | 7.7 | 7.9 |
| Conductivity (mhos/cm) | 422 | 418 | 388 |
| pH | 6.5 | 6.9 | 7.1 |
| Current Velocity (m/sec) | 0.16 | 0 | 0.36 |
| Turbidity (Secchi Depth-m) | 1.1 | 0.7 | 0.7 |

Temperature was observed to be relatively constant within all habitat areas. DO was found to be lowest at the upstream limit of the study area around RM 340.5, and was only slightly higher within the backwater habitat areas. DO was highest in the vicinity of RM 341.5 to 343.0, possibly accounting for the presence of several different vertebrate species encountered in this area which were not collected from the other habitat areas. Conductivity was very similar in the upstream portion of the study area and in backwater areas, while conductivity between RM 341.5 and RM 343.0 was somewhat lower. Between RM 340.5 and RM 343.0, pH was found to range from 6.5 to 7.1. The pH around RM 340.5 was found to be the lowest (6.5), while remaining habitat areas were found to be fairly neutral in regard to pH. As expected, backwater areas were lacking in any measurable current, while current velocities in the river channel ranged from 0.16 to 0.36 meters per second. Turbidity within habitat areas was measured using a secchi disk. As indicated by average measurements, turbidity was greatest within backwater areas and also within the habitat area between RM 342.0 and RM 343.0. Turbidity was somewhat lower around RM 340.5 as indicated by the greater secchi depth.

4.3 Threatened and Endangered Species

4.3.1 Indiana Bat Survey

The mist net survey conducted by BHE did not confirm the presence of Indiana Bat. Habitat potential was assessed as low to moderate, with scattered large cottonwoods in the mature woods providing the most likely potential roosting habitat. Three Big Brown Bat (*Eptesicus fuscus*) individuals were captured within the riparian forest outside the study area during the survey. Two individuals were pregnant females, and the third individual escaped before gender and reproductive condition could be determined. A copy of BHE's report is provided in Appendix C.

4.3.2 Mussel Survey

While conducting the mussel portion of the aquatic inventory for Greenup Locks and Dam, three species with special status within the state of Kentucky were collected by ESI between RM 342 and RM 343. *Obovaria retusa* (ring pink) was collected as a subfossil shell. This species is listed as endangered in the state of Kentucky and is also listed as endangered by the U.S. Fish & Wildlife Service. *Lampsilis ovata* (pocketbook) was collected and is also listed as a state endangered species. *Plethobasus cyphyus* (sheepnose) was collected during the aquatic inventory and is listed as a special concern species within the state of Kentucky. Only one vertebrate species with special status in Kentucky was identified during the aquatic inventory. *Notropis hudsonius* (spottail shiner) was collected during this inventory and is listed as a special concern species within Kentucky. Endangered species are defined by KSNPC as a taxon in danger of extirpation and/or extinction throughout all or a significant part of its range in Kentucky. Although species identified as “special concern” hold no state legal status, these species can be subject to monitoring for any of the following reasons:

- It exists in a limited geographic area.
- It may become threatened or endangered due to modification or destruction of habitat.
- Certain characteristics or requirements make it especially vulnerable to specific pressures.
- Experienced researchers have identified other factors that may jeopardize it.
- It is thought to be rare or declining but insufficient information exists for assignment to the threatened or endangered status categories.

A copy of the unionid inventory report prepared by ESI is included in Appendix B.

5.0 BASELINE HEP ASSESSMENT

5.1 Methodology

A modified/abbreviated HEP analysis was conducted on the study area to provide repeatable, quantified indices that can be used to evaluate the quality of the habitat for wildlife and a basis for mitigation needs. HEP methodology was first developed by the U.S. F&WS in response to the NEPA, which required all federal agencies to employ systematic and interdisciplinary techniques in planning and decision-making, and required “methods and procedures that will ensure environmental amenities and values that are presently not quantified may be given appropriate consideration in decision-making.” The results of this effort and descriptions of the methodology are provided in the *Habitat Evaluation Procedures Work Book* (National Ecology Research Center, 1980) as well as several other documents including the *Ecological Services Manual* (U.S. F&WS) and its subsequent releases (*Habitat as a Basis for Environmental Assessment ESM 101*, *Habitat Evaluation Procedures ESM 102*, *Development of Habitat Suitability Indices ESM 103*). Numerous HSI Models were also prepared by the U.S. F&WS as required elements of the HEP process.

The U.S. F&WS HEP analyses were found to be very laborious and too expensive for most smaller projects. Other authors and agencies in response to this problem have developed alternative methodologies. The same basic principles, procedures, and terminology are utilized in these other methodologies; however, the HSI models and data requirements are generally simpler and quicker. One of these alternate procedures is the Pennsylvania Modified HEP known as PAM HEP (Palmer, 1980) developed by the Pennsylvania Game Commission. The Pennsylvania Game Commission also produced a number of simplified HIS models for use in the procedures.

The PAM HEP methodology formed the basis of the subject HEP analysis; however, the process was further abbreviated in that not all PAM HEP forms were prepared, and in that the procedures were restricted to address only baseline existing conditions. Full HEP analyses project into the future to assess the differences in habitat quality that occur during and directly after construction as well as up to 50 years thereafter to account for changes in the habitat due to vegetation growth and succession as well as any additional project impacts.

The process of the subject HEP analysis was as follows:

- Map and classify the habitats found on the study area through aerial photograph interpretation and ground-truthing.
- Apply compartment identification numbers to each habitat map unit or polygon on the study area.
- Conduct field studies to determine the wildlife species that are common or abundant in habitat types on the study area.
- Select Evaluation Species per PAM HEP methodology for habitat evaluation via HSI models.
- Collect field data on habitat parameters (vegetation, soils, hydrology, limnology) that are used to determine Suitability Indices (SIs) for Life Requisites based on suitability index curves presented in the existing HSI models.
- Implement HSI models to calculate HSIs for each Evaluation Species in each study area habitat compartment in which it is believed to occur.
- Calculate average HSIs for each Evaluation Species found in the habitat over all compartments.
- Calculate the number of HUs on the entire study area under existing conditions, based upon the average HSI for each species in each habitat type, and the number of acres of each habitat type on the study area.

The number of HUs within any area that would be disturbed can then serve as a basis for assessing potential impacts to the area from the project, and any mitigation needs/requirements.

5.2 Habitat Mapping

The aerial photo interpretation and ground truthing procedures used to map the habitats on the study are described in Section 2.1.1. The resulting habitat maps are provided on Figure 2 and Figure 3 for the terrestrial and aquatic portions of the study area respectively. The habitat types found on the study area are described in Section 4.1 and Section 4.2.

Per PAM HEP and U.S. F&WS HEP procedures, each habitat map unit or compartment was ascribed to one of the major habitat categories (i.e., terrestrial, aquatic) and to a land use (terrestrial habitats) or wetland (wetland and aquatic habitats) classification. These systems are provided in detail in the PAM HEP instructional manual (Palmer, 1980) and follow the classification scheme developed by Anderson et al. (1976), for remote sensing studies of terrestrial landscapes and Cowardin et al. (1979), for wetland classification. Each of these classification schemes provides a numerical identifier for each specific land use category or wetland type (see Table 11 below). For this project each compartment was also identified as being one of the specific habitat types described in the mapping efforts in Sections 4.1 and 4.2. Each compartment was also given a compartment-specific identification number. The compartments mapped on the study area, their land use/wetland classifications, and their areas, are provided below in Table 11 and are indicated on the habitat maps on Figures 1 and 2.

Table 11. Land use/habitat type classification and compartments, target year: baseline.

| Habitat Category: Terrestrial | | | |
|-------------------------------|-----------------|------------------------------------|---------------|
| Compartment No. | Habitat Types | Land Use Category | Acreage |
| 1 | Riparian Forest | 415 Deciduous forest - mature | 47 ac |
| 2-1 | River Bank | 411 Deciduous forest - sapling | 4.5 ac |
| 2-2 | River Bank | 411 Deciduous forest - sapling | 4.5 ac |
| 3 | Open Field | 311 Mowed rangeland | 83 ac |
| 4 | Developed | 14 Builtup land - transportation | 27 ac |
| Total | | | 166 ac |
| | | | |
| Habitat Category: Aquatic | | | |
| Compartment No. | Habitat Types | Land Use Category | Acreage |
| 5 | Backwater | 652 Lower perennial unconsolidated | 23 ac |
| 6 | Lower Riverine | 652 Lower perennial unconsolidated | 210 ac |
| 7 | Upper Riverine | 652 Lower perennial unconsolidated | 40 ac |
| Total | | | 273 ac |
| Grand Total | | | 439 ac |

5.3 **Guilding**

A guilding approach was utilized in the selection of evaluation species for the HEP analysis. The term guild refers to an abstract grouping of species according to some ecological similarity. Root (1967) first defined guilds as groups of species that utilize a common class of environmental resources in a similar way. According to this definition guilds may be species grouped together based on such things as generalized diet (omnivore, herbivore, granivore, etc.), feeding substrate (ground, aerial, foliage, bark, water surface, earth, etc.), feeding technique (grazer, gleaner, excavator, diver, scavenger, etc.), nesting/breeding site (cavity, burrow, etc.), or any number of other aspects of resource use. The present study utilizes guilding in this sense.

Guilding has also been defined as a group of species that respond similarly to perturbations in habitat conditions (Szaro, 1986). This second definition is a logical corollary of the first definition and the crux of the use of guilding in HEP analyses. If all species in a guild use a particular resource, or resources in a similar fashion, then disturbances to that resource will affect all the species in the guild similarly if not to the same degree. This is particularly true when the guilds are defined or generated for specific habitat types. Logically, one should therefore be able to assess the impact of a given activity or habitat perturbation on a few species within the guild, and then extrapolate the impact over all species in the guild. If all the species occurring in a given habitat, within a given area, are guilded, then the impact can be assessed for a few representative species from each guild, and then be extrapolated to all species in that habitat/area. Similarly, if HEP evaluation species are selected from each guild for the HEP analysis, most if not all of the impacts that the habitat perturbation will have on wildlife will be considered and assessed. The use of guild analyses in habitat assessments has, however, been a subject of debate (Sveringhaus, 1981; Thomas, 1982; Landres, 1983; Vermeer, 1984; DeGraaf and Chadwick, 1984; Szaro, 1986). The practice has been tested with respect to HEP and been found to be successful, at least for nongeneralist or specialist species (Bayer and Porter, 1989).

The guilding process for the subject study followed that indicated in the PAM HEP instructional model (Palmer, 1985), published guilding systems (DeGraaf et al., 1985), and general life history information on the subject species. Results of the guilding effort are provided below, by habitat type, in Tables 12 through 17, for all species documented as occurring on the study area during the field surveys.

Table 12. Results of guilding species observed in terrestrial riparian forest habitat.

| Selected Evaluation Species | Candidate Evaluation Species | | | | Diet | | Feeding Site | | | Breeding Site | | | Habitat | | Evaluation Suitability Ranking | | | |
|-----------------------------|------------------------------|-------------|----------|-----------|-------|--------|--------------|------------------|-------------|---------------|-------|--------|------------------|-------------|--------------------------------|-------------------------|--------------------|------------|
| | Herbivore | Insectivore | Omnivore | Carnivore | Water | Ground | Air | Herbaceous Layer | Shrub Layer | Tree Layer | Water | Ground | Herbaceous Layer | Shrub Layer | Tree Layer | Riparian Forest (Woods) | River Bank (Shore) | Open Field |
| Mallard | | X | | X | X | X | | | | | X | X | | | | X | X | 6 |
| Ruby-throated Hummingbird | | X | | | | | | X | X | | | | | | | X | X | 6 |
| Cedar Waxwing | | X | | | | X | | | X | | | | | | | X | X | 5 |
| Green Heron | | | X | X | | | | | | X | X | | | | | X | X | 5 |
| Northern Cardinal | | X | | | X | X | X | X | | | X | X | X | | | X | X | 9 |
| Blue Jay | | X | | | X | | | X | X | | | | X | X | X | | | 7 |
| X Pileated Woodpecker | X | | | | X | | | X | | | | | | | X | X | | 5 |
| Gray Catbird | | X | | | X | X | X | | | | | X | X | | | X | | 7 |
| Common Yellowthroat | | X | | | | | | X | X | | | X | X | | | X | | 6 |
| X Wood Thrush | | X | | | X | | | | | | | X | X | X | | X | | 5 |
| Song Sparrow | | X | | | X | X | X | | | | X | X | | X | | | X | 8 |
| Great-crested Flycatcher | X | | | | | X | | X | X | | | | | X | X | X | | 7 |
| Tufted Titmouse | | X | | | | | | | X | X | | | | X | X | | | 5 |
| Indigo Bunting | | X | | | | | | X | X | | | X | X | | | X | | 6 |
| Hairy Woodpecker | X | | | | | | | | X | X | | | X | X | X | | | 6 |
| Rufous-sided Towhee | | X | | | X | X | X | | | | | X | | | | X | | 6 |
| Common Grackle | | X | | | X | X | | | | | | X | X | X | | | | 6 |
| American Redstart | | X | | | | X | | X | X | | | | X | X | | | | 6 |
| Carolina Wren | | X | | | | | | X | X | | | | X | | | X | | 5 |
| Brown Thrasher | | X | | | X | X | X | | | | | X | | | | X | | 6 |
| American Robin | | X | | | X | | | | X | | | | X | X | X | | | 6 |
| Carolina Chickadee | | X | | | | | | | X | X | | | | X | X | | | 5 |
| X Red-eyed Vireo | X | | | | | | | | X | X | | | | X | X | X | | 6 |
| Shorttail Shrew | | X | | | X | | X | | | | X | | | | | X | | 5 |
| Opossum | | X | | | X | | | | X | X | | | | X | X | | | 6 |
| Big Brown Bat | | X | | | | | X | | | | | | | X | X | | | 4 |
| X White-tailed Deer | X | | | | | X | | | | | X | | | | X | X | X | 6 |
| Deer Mouse | | X | | | X | | | | | | X | X | | | X | | | 5 |
| X Raccoon | | X | | X | X | | | X | X | | | | X | X | X | | | 8 |
| Eastern Chipmunk | | X | | | X | | | | | | X | | | X | | | | 4 |
| X Eastern Box Turtle | | | X | | X | X | X | | | | X | | | X | | | | 5 |

Table 13. Results of guilding species observed in the terrestrial river bank habitat.

| Selected Evaluation Species | Candidate Evaluation Species | | | | Diet | | Feeding Site | | | Breeding Site | | Habitat | Evaluation Suitability Ranking | | | |
|-----------------------------|------------------------------|-------------|----------|-----------|-------|--------|--------------|------------------|-------------|---------------|-------|---------|--------------------------------|-------------|------------|---|
| | Herbivore | Insectivore | Omnivore | Carnivore | Water | Ground | Air | Herbaceous Layer | Shrub Layer | Tree Layer | Water | Ground | Herbaceous Layer | Shrub Layer | Tree Layer | |
| Ruby-throated Hummingbird | | X | | X | | | | | X | X | X | X | X | X | X | 6 |
| Canada Goose | X | | | | X | X | | | | | X | X | X | X | X | 8 |
| Common Crow | | X | | | | X | | | | | | | X | X | X | 4 |
| American Coot | | X | | X | | | | | | | X | X | | X | X | 5 |
| X Belted Kingfisher | | | X | X | | | | | | X | | | | X | X | 5 |
| Great-crested Flycatcher | | X | | | | X | | X | X | | | | X | X | X | 7 |
| Double-crested Cormorant | | | X | X | | | | | | | | X | | X | X | 4 |
| X Red-eyed Vireo | | X | | | | | | X | X | | | | X | X | X | 6 |
| X White-tailed Deer | X | | | | | X | | | | | X | | X | X | X | 6 |
| X Beaver | X | | | | X | X | | | | X | | | | X | X | 5 |
| X Raccoon | | X | | X | X | | | X | X | | | | X | X | X | 9 |
| Red Fox | | X | | | X | | | | | | X | | | X | | 4 |
| Eastern Painted Turtle | | X | | X | | | | | X | X | | | X | | | 5 |

Table 14. Results of guilding species observed in the terrestrial open field habitat.

| Selected Evaluation Species | Candidate Evaluation Species | | | | | Diet | | Feeding Site | | | Breeding Site | | | Habitat | Evaluation Suitability Ranking | | | | |
|-----------------------------|------------------------------|-------------|----------|-----------|-------|--------|-----|------------------|-------------|-----------|---------------|--------|------------------|-------------|--------------------------------|-------------------------|--------------------|------------|---|
| | Herbivore | Insectivore | Omnivore | Carnivore | Water | Ground | Air | Herbaceous Layer | Shrub Layer | Tre Layer | Water | Ground | Herbaceous Layer | Shrub Layer | Tree Layer | Riparian Forest (Woods) | River Bank (Shore) | Open Field | |
| | Red-winged Blackbird | X | | X | X | X | | X | | | X | X | X | X | | X | X | X | 6 |
| | Canada Goose | X | | | X | X | | | | | X | X | X | | | X | X | X | 8 |
| X | Red-tailed Hawk | | | X | X | | | | | | | | | X | X | | X | X | 5 |
| | Turkey Vulture | | | X | X | | | | | | | X | | | | | X | | 4 |
| | Killdeer | X | | | X | X | | | | | X | | | | | | X | | 5 |
| | Yellow-shafted Flicker | X | | | | X | | X | | | | | X | | | | X | | 5 |
| | Barn Swallow | X | | | | | X | | | | | | | | | | X | | 3 |
| | Baltimore Oriole | | X | | | | | | X | | | | | X | | | X | | 4 |
| | Belted Kingfisher | | | X | X | | | | | | X | | | | | X | X | | 5 |
| | Song Sparrow | | X | | | X | | X | X | | | | X | X | | X | X | | 8 |
| | Purple Martin | X | | | | | | X | | | | | | | | | X | | 3 |
| | Easter Bluebird | X | | | | X | | X | | | | | | X | | | | X | 6 |
| X | Eastern Meadowlark | X | | | | X | | X | | | X | X | | | | | X | | 6 |
| | European Starling | | X | | | X | | X | | | | | X | | | | X | | 5 |
| | Mourning Dove | X | | | | X | | | | | | | X | | | | X | | 4 |
| | | | | | | | | | | | | | | | | | | | |
| | Woodchuck | X | | | | X | | | | | X | | | | | | X | | 4 |
| X | Meadow Vole | | X | | | X | | | | | X | | | | | | X | | 4 |
| | Eastern Harvest Mouse | | X | | | X | | | | | X | | | | | | X | | 4 |
| X | Eastern Cottontail | X | | | | X | | | | | X | | | | | | X | | 4 |

Table 15. Results of guilding species observed in aquatic backwater habitats.

Table 16. Results of guilding species observed in aquatic lower riverine habitats.

| Selected Evaluation Species | Candidate Evaluation Species | | | | Diet | Spawning | Habitat | Evaluation Suitability Ranking |
|-----------------------------|------------------------------|-------------|----------|-----------|-------------|------------------|---------|--------------------------------|
| | Herbivore | Insectivore | Omnivore | Carnivore | | | | |
| X Eastern Gizzard Shad | | X | | | Aquatic Bed | Rock/Gravel/Sand | | 7 |
| Common Emerald Shiner | | X | | | | X X X | X X X | 6 |
| X White Bass | | | X | X | | | X X | 3 |
| Central Longear Sunfish | | X | | | X | | X X | 4 |
| X Northern Bluegill Sunfish | | X | X | X X | | X | X X | 6 |
| Longnose Gar | | | X X | X | | | X X | 5 |
| Northern River Carpsucker | X | | | | X X | | X X | 5 |
| Northern Rockbass | | | X X | | | | X | 3 |
| Black Redhorse | X | | | | X | | X | 3 |
| Spotfin Shiner | X | | | | X X | | X | 4 |
| Sand Shiner | X | | | | X X | | X | 4 |
| River Shiner | X | | | | X X | | X | 4 |
| Golden Redhorse | X | | | | X | | X | 3 |
| Silver Redhorse | X | | | | X | | X | 3 |
| Spottail Shiner | X | | | | X X | | X | 4 |
| Spotted Blackbass | | | X X | X X | | | X | 5 |

Table 17. Results of guilding species observed in aquatic upper riverine habitats.

| Selected Evaluation Species | Candidate Evaluation Species | Diet | | | | Spawning Substrate | | | Habitat | | | Evaluation Suitability Ranking |
|-----------------------------|------------------------------|-----------|-------------|----------|-----------|--------------------|------------------|------------------|---------|-------------------|---------------------|--------------------------------|
| | | Herbivore | Insectivore | Omnivore | Carnivore | Aquatic Bed | Rock/Gravel/Sand | Debris/Structure | Mud | Riverine-Upstream | Riverine-Downstream | |
| X | Eastern Gizzard Shad | | | X | | X | X | X | X | X | X | 7 |
| X | Flathead Catfish | | | X | | X | X | X | | | X | 4 |

5.4 Evaluation Species

Evaluation species were selected for HEP analysis for each habitat type based upon (1) guidelines in the PAM HEP instructional manual; (2) the guilds developed for the project (above); (3) documented occurrence of the species within the habitat on the study area; (4) the availability of existing HSI (U.S. F&WS and PAM HEP) models important game or recreational/commercial fish; and (5) whether the species was ecologically representative or characteristic of the habitat type. Secondarily, we also considered the evidence that HEP analyses work best when the evaluation species are not generalists, i.e., species that are cosmopolitan with wide niches, diets, feeding strategies, or habitat requirements. An effort was also made to include representatives from the major class taxons, i.e., mammals, birds, reptiles, amphibians, fish, where possible.

The PAM HEP instructional manual recommends that five evaluation species be selected for each major habitat category in this case (terrestrial upland, terrestrial wetland, and aquatic), and that at least two evaluation species be selected from each habitat type within the category. Habitat characterization efforts for this study determined that only two habitat categories occur on the study area – terrestrial upland and aquatic. Field surveys found three habitat types (riparian forest, field, and shoreline) on the study area that fall under the terrestrial upland category, and three habitat types (upper riverine, lower riverine, backwater) in the aquatic category.

Species were selected by habitat type first to ensure that all habitat types were represented by at least two species per the PAM HEP instructional manual. Then species were selected from the list of species observed on the study area per the five criteria listed above. Evaluation species selected specifically as representatives of the respective habitat types, and the rationale for selection, are presented in Tables 18 and 19. Each habitat type was represented by at least two species, and each habitat category was represented by at least five species.

Table 18. Evaluation species selected specifically as representative species for each terrestrial habitat type for the HEP analysis.

| Land Category | Habitat Type | Evaluation Species | Selection Considerations |
|---------------|-----------------|---------------------|--|
| Terrestrial | Riparian Forest | White-tailed Deer | important game mammal, large herbivore, ground breeder, existing model |
| | Riparian Forest | Pileated Woodpecker | bird, cavity nester, insectivore, high ranking, requires relatively mature forests, existing model |
| | Riparian Forest | Wood Thrush | bird, omnivore, ground feeder, shrub nester, characteristic mature forest – especially deciduous, model exists |
| | Riparian Forest | Red-eyed Vireo | bird, insectivore, tree and shrub layer feeder and nester, foliage gleaner, high score, model exists |
| | Riparian Forest | Eastern Box Turtle | reptile, omnivore, only reptile observed in the study area, existing model |
| Terrestrial | Open Field | Meadow Vole | abundant, small mammal, nests on ground/subterranean, granivorous, important prey species, model exists |
| | Open Field | Eastern Cottontail | common on study area, nests on ground, herbivore, game mammal, prey species, model exists |
| | Open Field | Red-tailed Hawk | large bird, raptor, aerial/ground feeder, carnivorous, high score, tree layer nester, existing model |
| | Open Field | Eastern Meadowlark | bird, abundant, characteristic of field, feeds in herbaceous layer, ground nester, model exists |
| Terrestrial | River Bank | Beaver | semiaquatic mammal, fur bearer, land/water feeder, herbivore, typical of shore/riverine habitat, model |
| | River Bank | Northern Raccoon | mammal, omnivore in aquatic and terrestrial habitat, typical of shore/riverine habitat, model exists |
| | River Bank | Belted Kingfisher | bird, piscivorous, nests in the ground, characteristic of riverine riparian habitat, specialist, model |

Table 19. Evaluation species selected specifically as representative species for each aquatic habitat type for the HEP analysis.

| Land Category | Habitat Type | Evaluation Species | Selection Considerations |
|---------------|--------------|---------------------------|--|
| Aquatic | Upper River | Eastern Gizzard Shad | fish, omnivore in water column, 1 of only 2 spp in upper river, important prey spp, model exists |
| | Upper River | Flathead Catfish | fish, top carnivore, demersal feeder, 1 of only 2 spp in upper river, model exists |
| Aquatic | Lower River | Northern Bluegill Sunfish | fish, small omnivore, high score, model exists |
| | Lower River | White Bass | fish, large carnivore, important game fish, model exists |
| Aquatic | Backwater | Northern Black Bass | fish, large carnivore, important game fish, high score, model exists |
| | Backwater | Smallmouth Buffalofish | Fish, omnivore, feeds on bottom, requires rock/sand/gravel spawn, model exists |

These evaluation species were also used to evaluate any other habitat type on the study area in which they were known to occur. The total lists of evaluation species evaluated for each habitat type are presented in Table 20.

**Table 20. HEP evaluation species evaluated for each habitat type on the study area,
target year: baseline.**

| | | |
|--------------------|------------------------|-------------------------------|
| Terrestrial | Riparian Forest | White-tailed Deer |
| | | Northern Raccoon |
| | | Wood Thrush |
| | | Red-tailed Hawk |
| | | Red-eyed Vireo |
| | | Pileated Woodpecker |
| | | Eastern Box Turtle |
| | River Bank | White-tailed Deer |
| | | Northern Raccoon |
| | | Beaver |
| Aquatic | | Red-eyed Vireo |
| | | Belted Kingfisher |
| | | Red-tailed Hawk |
| | Open Field | White-tailed Deer |
| | | Northern Raccoon |
| | | Eastern Cottontail |
| | | Meadow Vole |
| | | Eastern Meadowlark |
| | | Red-tailed Hawk |
| | Developed | none |
| Aquatic | Backwater | Eastern Gizzard Shad |
| | | Northern Largemouth Blackbass |
| | | Northern Bluegill Sunfish |
| | | Smallmouth Buffalofish |
| | Lower Riverine | Eastern Gizzard Shad |
| | | White Bass |
| | | Northern Bluegill Sunfish |
| | Upper Riverine | Eastern Gizzard Shad |
| | | Flathead Catfish |
| | | |

5.5 Habitat Suitability Indices (HSIs)

HSIs were calculated using data collected in the field and published HEP or HSI models for the Evaluation Species. All published models utilized for this project were from one of two sources: those published by the U.S. F&WS (Habitat Suitability Index Models or “Blue Books”), and those published by the Pennsylvania Game Commission (PAM HEP HSI Models). The source and author of the model used for each species is provided below in Table 21. The full citations of the models are provided by author in the literature cited section.

Table 21. HSI models used to evaluate the habitat.

| Evaluation Species | Source | Author / Date |
|-------------------------------|-----------|----------------------------------|
| White-tailed Deer | PAM HEP | Palmer and Lang 1994 |
| Northern Raccoon | PAM HEP | Palmer 1994 |
| Beaver | U.S. F&WS | Allen 1982 |
| Meadow Vole | PAM HEP | Palmer 1994 |
| Eastern Cottontail | PAM HEP | Palmer 1994 |
| Red-tailed Hawk | PAM HEP | Palmer 1994 |
| Red-eyed Vireo | U.S. F&WS | Anonymous 1978 |
| Wood Thrush | PAM HEP | Palmer 1994 |
| Pileated Woodpecker | U.S. F&WS | Schroeder 1982 |
| Belted Kingfisher | PAM HEP | Palmer 1994 |
| Eastern Meadowlark | PAM HEP | Palmer 1994 |
| Eastern Box Turtle | PAM HEP | McCoy 1983 |
| Gizzard Shad | U.S. F&WS | Williamson and Nelson 1985 |
| Flathead Catfish | U.S. F&WS | Lee and Terrell 1987 |
| Smallmouth Buffalofish | U.S. F&WS | Edwards and Twomey 1982 |
| White Bass | U.S. F&WS | Hamilton and Nelson 1984 |
| Northern Bluegill | U.S. F&WS | Stuber, Gebhart and Maughan 1982 |
| Northern Largemouth Blackbass | U.S. F&WS | Stuber, Gebhart and Maughan 1982 |

Each HSI model has several components which are defined below.

Life Requisite: Life requisite is a critical aspect, activity, life stage, or portion of the natural history of the species for which habitat characteristics have a bearing on the ability of the habitat to support the species. Common life requisites include food, reproduction, breeding, cover, water quality, and similar parameters.

Variable: Variables are the habitat parameters used to evaluate the suitability of a habitat in fulfilling the life requisite. Such variables or parameters include plant species composition,

foliage height, canopy closures, snag/cavity/perch density, ground cover, soil moisture, water temperature, water depth, etc.

Suitability Curves or Index Graphs: A suitability curve, developed from the scientific literature, is presented for each variable in the existing models. The suitability curve may be in the form of a linear or curvilinear regression, or some other nonlinear relationship between the status or condition of the variable and the suitability of the habitat to fulfill the life requisite.

Suitability Index: Suitability indices (SIs) are read off the suitability curve, which ranks the variable from 0.0 (not suitable) to 1.0 (optimum). SIs for each variable are entered in the HSI model, which is a mathematical expression of the relationship of the variables and their effect on suitability. The model provides an SI for each life requisite.

Habitat Suitability Index (HSI): The HSI model provides a mathematical expression of the relationship of the life requisites. The life requisite SIs are entered into the equations in the model. The result is an overall HSI for that evaluation species for that compartment of that habitat type. The HSI is in the same format as the life requisite SIs with 0.0 being unsuitable and 1.0 being optimal.

The HSIs calculated for each evaluation species in each habitat compartment on the study area are presented in Tables 22 through 28.

Table 22. Habitat compartment HSI evaluation for Riparian Forest Compartment 1.

Project: Greenup Lock and Dam Expansion

Land Use / Cover Type: terrestrial, deciduous forest, mature stage, shrub layer moderate-dense

Habitat Type: riparian forest

Compartment No.: 1

Area: 47.0 ac

Topography: nearly level to gently rolling

Tree Cover: silver maple, box elder, American elm

Shrub Cover: box elder, American elm,

Herbaceous Cover: cleavers, wingstem, poison ivy, wood nettle

| Evaluation Species | Life Requisite | Requisite Ranking | | | HSI |
|---------------------------|-----------------------|--------------------------|----------|----------|------------|
| | | A | B | C | |
| white-tailed deer | food | 0.750 | | | 0.166 |
| | cover | 0.166 | | | |
| | limiting factors | | | | |
| northern raccoon | breeding | 0.250 | | | 0.250 |
| | food | 0.583 | | | |
| | water | 1.000 | | | |
| | limiting factors | | | | |
| wood thrush | breeding | 0.500 | | | 0.400 |
| | food | 0.833 | | | |
| | cover | 0.400 | | | |
| | limiting factors | | | | |
| red-tailed hawk | food | 0.950 | | | 0.950 |
| | breeding | 1.000 | | | |
| | limiting factors | | | | |
| red-eyed vireo | reproduction/cover | 0.841 | | | 0.707 |
| | food value | 0.707 | | | |
| | limiting factors | | | | |
| pileated woodpecker | food/cover/reprod | 0.132 | | | 0.132 |
| | limiting factors | | | | |
| eastern box turtle | breeding | 1.000 | | | 1.000 |
| | cover | 1.000 | | | |

Table 23. Habitat compartment HSI evaluation for River Bank Compartment 2-1.

Project: Greenup Lock and Dam Expansion

Land Use / Cover Type: terrestrial, deciduous forest, pole stage, shrub layer moderate-dense

Habitat Type: river bank

Compartment No.: 2-1

Area: 4.5 ac

Topography: steep to nearly level

Tree Cover: black willow

Shrub Cover: black willow

Herbaceous Cover: field horsetail, lambs quarters, beggar's tick

| Evaluation Species | Life Requisite | Requisite Ranking | | | HSI |
|---------------------------|-----------------------|--------------------------|----------|----------|------------|
| | | A | B | C | |
| white-tailed deer | food | 0.750 | | | 0.166 |
| | cover | 0.166 | | | |
| | limiting factors | | | | |
| northern raccoon | breeding | 0.250 | | | 0.250 |
| | food | 0.583 | | | |
| | water | 1.000 | | | |
| | limiting factors | | | | |
| beaver | winter food | 1.000 | | | 0.500 |
| | water | 0.500 | | | |
| | limiting factors | | | | |
| red-eyed vireo | reproduction/cover | 0.000 | | | 0.000 |
| | food | 0.000 | | | |
| | limiting factors | | | | |
| belted kingfisher | breeding | 1.000 | | | 0.825 |
| | food/cover | 0.825 | | | |
| | limiting factors | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

Table 24. Habitat compartment HSI evaluation for River Bank Compartment 2-2.

Project: Greenup Lock and Dam Expansion

Land Use / Cover Type: terrestrial, deciduous forest, pole stage, shrub layer moderate-dense

Habitat Type: river bank

Compartment No.: 2-2

Area: 4.5 ac

Topography: steep to nearly level

Tree Cover: black willow

Shrub Cover: black willow

Herbaceous Cover: field horsetail, lambs quarters, beggar's tick

| Evaluation Species | Life Requisite | Requisite Ranking | | | HSI |
|---------------------------|-----------------------|--------------------------|----------|----------|------------|
| | | A | B | C | |
| white-tailed deer | food | 0.750 | | | 0.166 |
| | cover | 0.166 | | | |
| | limiting factors | | | | |
| northern raccoon | breeding | 0.250 | | | 0.250 |
| | food | 0.583 | | | |
| | water | 1.000 | | | |
| | limiting factors | | | | |
| beaver | winter food | 1.000 | | | 0.500 |
| | water | 0.500 | | | |
| | limiting factors | | | | |
| red-eyed vireo | reproduction/cover | 0.000 | | | 0.000 |
| | food | 0.000 | | | |
| | limiting factors | | | | |
| belted kingfisher | breeding | 1.000 | | | 0.825 |
| | food/cover | 0.825 | | | |
| | limiting factors | | | | |

Table 25. Habitat compartment HSI evaluation for Open Field Compartment 3.

Project: Greenup Lock and Dam Expansion

Land Use / Cover Type: terrestrial, herbaceous rangeland, mowed areas

Habitat Type: Open Field

Compartment No.: 3

Area: 83.0 ac

Topography: nearly level to gently rolling

Tree Cover: none

Shrub Cover: none

Herbaceous Cover: fescue

| Evaluation Species | Life Requisite | Requisite Ranking | | | HSI |
|---------------------------|-----------------------|--------------------------|----------|----------|------------|
| | | A | B | C | |
| white-tailed deer | food | 1.000 | | | 0.750 |
| | cover | 0.750 | | | |
| | limiting factors | | | | |
| northern raccoon | breeding | 0.500 | | | 0.400 |
| | food | 0.400 | | | |
| | water | 1.000 | | | |
| | limiting factors | | | | |
| eastern cottontail | breeding | 0.500 | | | 0.400 |
| | cover | 0.400 | | | |
| | limiting factors | | | | |
| meadow vole | food/cover | 0.775 | | | 0.775 |
| | limiting factors | | | | |
| red-tailed hawk | food | 1.000 | | | 0.833 |
| | breeding | 0.833 | | | |
| | limiting factors | | | | |
| eastern meadowlark | breeding/cover | 0.880 | | | 0.880 |

Table 26. Habitat compartment HSI evaluation for Backwater Compartment 5.

Project: Greenup Lock and Dam Expansion

Land Use / Cover Type: aquatic, lower perennial, unconsolidated bottom

Habitat Type: Backwater

Compartment No.: 5

Area: 23 ac

Bathymetry: nearly level; water depth 5-11 ft

Description: substrate mixture of clay, silt, cobble, sand, gravel

| Evaluation Species | Life Requisite | Requisite Ranking | | | HSI |
|---------------------------|-----------------------|--------------------------|----------|----------|------------|
| | | A | B | C | |
| eastern gizzard shad | food | 0.800 | | | 0.700 |
| | water quality | 0.800 | | | |
| | reproduction | 0.700 | | | |
| | limiting factors | | | | |
| northern largemouth | food | 0.477 | | | 0.772 |
| blackbass | cover | 0.857 | | | |
| | water quality | 0.670 | | | |
| | other | 1.000 | | | |
| | limiting factors | | | | |
| northern bluegill | food | 0.794 | | | 0.878 |
| sunfish | cover | 0.750 | | | |
| | water quality | 0.853 | | | |
| | reproduction | 1.000 | | | |
| | other | 0.900 | | | |
| | limiting factors | | | | |
| small mouth buffalo fish | food/cover | 0.632 | | | 0.765 |
| | water quality | 0.900 | | | |
| | reproduction | 0.877 | | | |
| | other | 0.525 | | | |
| | limiting factors | | | | |

Table 27. Habitat compartment HSI evaluation for Lower Riverine Compartment 6.

Project: Greenup Lock and Dam Expansion

Land Use / Cover Type: aquatic, lower perennial, unconsolidated bottom

Habitat Type: Lower Riverine

Compartment No.: 6

Area: 210 ac

Bathymetry: nearly level; 1-5 ft water depth

Description: substrate sand and silt; shoreline riprap and vegetation

| Evaluation Species | Life Requisite | Requisite Ranking | | | HSI |
|---------------------------|-----------------------|--------------------------|----------|----------|------------|
| | | A | B | C | |
| eastern gizzard shad | food | 0.800 | | | 0.466 |
| | water quality | 0.800 | | | |
| | reproduction | 0.466 | | | |
| | limiting factors | | | | |
| white bass | food | 1.000 | | | 0.559 |
| | cover | 0.466 | | | |
| | water quality | 0.375 | | | |
| | limiting factors | | | | |
| northern bluegill | food | 0.707 | | | 0.883 |
| sunfish | cover | 0.850 | | | |
| | water quality | 0.874 | | | |
| | reproduction | 1.000 | | | |
| | other | 0.900 | | | |
| | limiting factors | | | | |
| | | | | | |

Table 28. Habitat compartment HSI evaluation for Upper Riverine Compartment 7.

Project: Greenup Lock and Dam Expansion

Land Use / Cover Type: aquatic, lower perennial, unconsolidated bottom

Habitat Type: Upper Riverine

Compartment No.: 7

Area: 40 ac

Bathymetry: nearly level;

Description:

| Evaluation Species | Life Requisite | Requisite Ranking | | | HSI |
|---------------------------|-----------------------|--------------------------|----------|----------|------------|
| | | A | B | C | |
| eastern gizzard shad | food | 0.800 | | | 0.466 |
| | water quality | 0.800 | | | |
| | reproduction | 0.466 | | | |
| flathead catfish | limiting factors | | | | |
| | adult cover | 0.570 | | | 0.570 |
| | limiting factors | | | | |

5.6 Baseline Habitat Units (HUs)

An HU is defined as the equivalent of 1.0 acres of habitat with an HSI value of 1.0 (optimal habitat). HUs are calculated for compartments as the product of the HSI for a given species in that compartment and the number of acres in the compartment ($HUs = HSI \times \text{acres}$). Because an HU is an equivalent measure, 1.0 HU may be represented by 1.0 acres of habitat with an HSI of 1.0, 2.0 acres of habitat with an HSI of 0.5, or any other combination with a product of 1.0.

Table 29 lists the baseline conditions for the terrestrial habitat on site with a total HUs of 629.235. Table 30 lists the baseline conditions for the aquatic habitat on site with a total HUs of 524.925.

Table 29. Baseline conditions HUs for each evaluation species for each terrestrial habitat type on the study area and for the entire study area.

| Evaluation Species | Habitat Type | HSI Value | Acreage | Habitat Units |
|---------------------|--------------------|-----------|---------|---------------|
| White-tailed Deer | Riparian Forest | 0.166 | 47.0 | 7.802 |
| | River Bank | 0.166 | 9.0 | 1.494 |
| | Open Field | 0.750 | 83.0 | <u>62.250</u> |
| | Species Total | | | 71.546 |
| Northern Raccoon | Riparian Forest | 0.250 | 47.0 | 11.750 |
| | River Bank | 0.250 | 9.0 | 2.250 |
| | Open Field | 0.400 | 83.0 | <u>32.200</u> |
| | Species Total | | | 47.200 |
| Beaver | River Bank | 0.500 | 9.0 | <u>4.500</u> |
| | Species Total | | | 4.500 |
| Meadow Vole | Open Field | 0.775 | 83.0 | <u>64.325</u> |
| | Species Total | | | 64.325 |
| Eastern Cottontail | Open Field | 0.833 | 83.0 | <u>69.139</u> |
| | Species Total | | | 69.139 |
| Red-tailed Hawk | Riparian Forest | 0.950 | 47.0 | <u>44.650</u> |
| | Open Field | 0.833 | 83.0 | |
| | Species Total | | | 69.139 |
| Wood Thrush | Riparian Forest | 0.400 | 47.0 | <u>18.800</u> |
| | Species Total | | | 18.800 |
| Red-eyed Vireo | Riparian Forest | 0.707 | 47.0 | 32.229 |
| | River Bank | 0.000 | 9.0 | <u>0.000</u> |
| | Species Total | | | 32.229 |
| Pileated Woodpecker | Riparian Forest | 0.132 | 47.0 | <u>6.204</u> |
| | Species Total | | | 6.204 |
| Belted Kingfisher | River Bank | 0.825 | 9.0 | <u>7.425</u> |
| | Species Total | | | 7.425 |
| Eastern Meadowlark | Open Field | 0.880 | 83.0 | <u>73.040</u> |
| | Species Total | | | 73.040 |
| Eastern Box Turtle | Riparian Forest | 1.000 | 47.0 | <u>47.000</u> |
| | Species Total | | | 47.000 |
| All Species | Project Area Total | | 434.0 | 629.235 |

Table 30. Baseline conditions HUs for each evaluation species for each aquatic habitat type on the study area and for the entire study area.

| Evaluation Species | Habitat Type | HIS Value | Acreage | Habitat Units |
|------------------------------|--------------------|-----------|---------|----------------|
| Eastern Gizzard Shad | Backwater | 0.800 | 23.0 | 18.400 |
| | Lower Riverine | 0.466 | 210.0 | 97.860 |
| | Upper Riverine | 0.466 | 40.0 | <u>18.640</u> |
| | Species Total | | 273.0 | 134.900 |
| White Bass | Lower Riverine | 0.599 | 210.0 | <u>125.790</u> |
| | Species Total | | | 125.790 |
| Northern Blackbass | Backwater | 0.792 | 23.0 | <u>18.216</u> |
| | Species Total | | | 18.216 |
| Northern Bluegill Sunfish | Backwater | 0.878 | 23.0 | 20.194 |
| | Lower Riverine | 0.883 | 210.0 | <u>185.430</u> |
| | Species Total | | | 205.624 |
| Smallmouth Buffalo | Backwater | 0.765 | 23.0 | <u>17.595</u> |
| | Species Total | | | 17.595 |
| Flathead Catfish | Upper Riverine | 0.570 | 40.0 | <u>22.800</u> |
| | Species Total | | | 22.800 |
| All Species | Project Area Total | | 273.0 | 524.925 |

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APPENDIX A
SCIENTIFIC WILDLIFE COLLECTING PERMIT

FISH & WILDLIFE COMMISSION

Mike Boatwright, Paducah
Tom Baker, Bowling Green
Allen K. Gailor, Louisville
Charles E. Bale, Hodgenville
Dr. James R. Rich, Taylor Mill
Ben Frank Brown, Richmond
Doug Hensley, Hazard
Dr. Robert C. Webb, Grayson
David H. Godby, Somerset



COMMONWEALTH OF KENTUCKY
DEPARTMENT OF FISH AND WILDLIFE RESOURCES
C. THOMAS BENNETT, COMMISSIONER

May 6, 1999

Ms. Jennifer Lynn Kelly, Environmental Scientist
Burgess and Nipke, Limited
5085 Reed Road
Columbus, OH 43220

Dear Ms. Kelly:

The Kentucky Department of Fish and Wildlife Resources (KDFWR) has entered into a cooperative agreement with the U. S. Fish and Wildlife Service pursuant to Section 6(c) of the Endangered Species Act of 1973 as amended, 15 U.S.C. Sections 1531-43 (hereinafter referred to as "the Act"), which enables its employees or agents to take federally endangered or threatened species, under specific conditions, for conservation purposes consistent with the purposes of the Act.

KDFWR has determined that your activity is in compliance with the Act and information gained may enhance the conservation of endangered or threatened species. Therefore, KDFWR is designating you as an agent of the Kentucky Department of Fish and Wildlife Resources. As such you will be responsible for adherence to the following provisions: no taking or collecting of federally threatened or endangered species will be allowed which will result in 1) the death or permanent disabling of the specimens; 2) the removal of the specimens from the state of Kentucky; 3) the introduction of the specimen or any of its progeny into an area beyond the historical range of the species; or 4) the holding of the specimen in captivity for a period of more than 45 consecutive days. Salvaged shells of dead threatened or endangered mussels, however, may be retained in your reference collection.

In order to facilitate your work, the following individuals listed on your collecting permit (Katherine E. Fontaine) may also participate in activities pertaining to threatened or endangered species according to the provisions detailed above. You, however, will be singularly responsible for making them aware of the provisions of this agent designation, 301 KAR 4:070 and all requirements assigned accordingly.

This designation will be effective until December 31, 1999. A copy of this letter shall be retained in the possession by yourself or others when in the field during collection trips.

If you should have any questions, please feel free to contact me.

Sincerely,

A handwritten signature in cursive ink, appearing to read "Roy A. Grimes".

Roy A. Grimes
Director
Wildlife Division

RAG:djc
cc: David Loveless
Pete Pfeiffer
Wayne Davis
Dan Figert
Earl Gray



KENTUCKY SCIENTIFIC WILDLIFE COLLECTING PERMIT

This permit authorizes Jennifer Lynn Kelly, Environmental Scientist
 • (Name) (Title)
 Burgess and Nipke, Limited

(Name of Company) 5085 Reed Road, Columbus, OH 43220 (Address) 614/459-2050 work 614/870-9512 home
 (Zip) 43220 (Phone) (Phone)

to collect the fish and wildlife species necessary to evaluate an area of land and/or water for the below stated purpose, except those species designated as threatened or endangered by state or federal law. This permit does not authorize the taking of any species for personal use or consumption. Sport fishing gear may not be possessed in the field while collecting. All collecting equipment, except firearms, while in use or being transported, must be marked with the permittee's name and address. Additions or deletions to the permit may be requested by letter or phone. Violation of fish and wildlife laws, or the provisions of this permit by any collector, will be grounds for revocation, without compensation, of this permit. A copy of this permit may be assigned to the persons named below. Permittees should contact local conservation officers before collecting in their county.

NAME OF OTHER PERSONS INVOLVED IN COLLECTIONS: Katherine E. Fontaine

PURPOSE OF COLLECTION: An environmental assessment: Obtaining taxonomic and distribution data and specimens.

SPECIES OR GROUPS OF FISH/WILDLIFE, NUMBERS: Fish, macroinvertebrates—
aquatic, mussels, small mammals, birds.

COLLECTING EQUIPMENT AUTHORIZED: for wildlife: live traps,
mist nets. For fish: electrofishing.

COLLECTING LOCALITY: Collectors must notify the Daniel Boone National Forest
Supervisor when collecting on National Forest Lands.
Greenup County, KY.

DISPOSITION OF SPECIMENS AND/OR SPECIAL CONDITIONS: All collected
specimens must be returned to the environment where collected, preserved for study or voucher,
or disposed of by burying. Zebra mussel is must NOT be returned to any KY waters.

THIS PERMIT EXPIRES: DECEMBER 31, 1999 1999

C. John Bentler Daryl Johnson
 Director, Division of Fisheries
 Commissioner, Department of Fish and Wildlife Resources



xc: Environmental Section Chief
 Major Earl Gray, Law Enforcement

APPENDIX B

**ECOLOGICAL SPECIALISTS, INC. -
UNIONID COMMUNITY CHARACTERIZATION**

Characterization of a Unionid Community near Greenup Locks and Dam: Ohio River Miles 340.5 to 343.0

Prepared for:
Burgess & Niple, Limited
Columbus, Ohio

Under Contract with:
U.S. Army Corps of Engineers, Huntington District
Huntington, West Virginia

Prepared by:
Ecological Specialists, Inc.
St. Peters, Missouri

June 1999
(ESI Project # 99-007)

Acknowledgements

This survey was conducted under contract to Burgess & Niple, Limited. Mr. David Mitchell served as Burgess & Niple's project manager. Ms. Heidi Dunn managed the project for Ecological Specialists, Inc. (ESI). Mr. Dan Kelner was ESI's field team leader. He was assisted by Mr. Bernard Sietman (ESI). Diving was conducted by Mainstream Commercial Divers, Inc. Mr. Sietman, Mr. Kelner, and Ms. Dunn prepared this report.

Table of Contents

| | |
|--|----|
| 1.0 Introduction..... | 1 |
| 2.0 Methods..... | 3 |
| 3.0 Results and Discussion | 5 |
| 3.1 Habitat Characteristics and Sampling Conditions..... | 5 |
| 3.2 Unionid Fauna..... | 5 |
| 4.0 Conclusions and Recommendations..... | 11 |
| 5.0 Literature Cited..... | 12 |

List of Figures

| | |
|--|---|
| Figure 2-1. Diving locations near Greenup Locks and Dam (ORM 340.5 to 343.0), May 1999. | 4 |
|--|---|

List of Tables

| | |
|--|----|
| Table 1-1. Recent unionid species records in the upper Ohio River..... | 2 |
| Table 3-1. Habitat characteristics along transects on the Ohio River near Greenup Locks and Dam, (ORM 340.5 to 343.0), May 1999. | 6 |
| Table 3-2. Unionid abundance along transects near Greenup Locks and Dam, (ORM 340.5 to 343.0), May 1999..... | 7 |
| Table 3-3. Comparison of unionid abundance and distribution along Transects 11 to 18. | 9 |
| Table 3-4. Unionid relative abundance and community characteristics near Greenup Locks and Dam, (ORM 340.5 to 343.0), May 1999. | 10 |

1.0 Introduction

The U.S. Army Corps of Engineers (USCOE) proposes extending the lock wall at Greenup Locks and Dam on the Ohio River. With the improving water and sediment quality in recent years (Cavanaugh and Mitsch, 1989; Pearson and Pearson, 1989; Youger and Mitsch, 1989), unionids have begun to flourish in many areas of the Ohio River. Recent studies have recorded 41 living and recently dead species in the upper river, 30 of which are present in Meldahl Pool (Table 1-1). These unionid communities are often diverse and the Federally listed species *Cyprogenia stegaria* and *Lampsilis abrupta* have been found in several areas (ESI, 1996a, 1996b, 1998a, and 1998b; Miller and Payne, 1995; P. Morrison-USFWS, pers. comm.).

USCOE is concerned that unionids may be affected by construction activities during lock wall modification. Unionids could be affected by construction activities in several ways. Unionids living in the construction area could be crushed or dislodged during sheet piling placement and removal, and lock wall construction. Cofferdam dewatering and removal may result in substrate disturbance and downstream siltation. Construction activities (such as staging equipment near banks and in the water, barge spudding, etc.) will also crush or dislodge animals, or disturb substrate and streambanks, possibly resulting in downstream sediment deposition. Additionally, fish host activity in a unionid bed may be altered by habitat changes and/or altered flow patterns.

Based on available information, the Kentucky side of the Ohio River between Ohio River Mile (ORM) 340 and 343 has never been sampled for unionids. USCOE therefore contracted Burgess & Niple and Ecological Specialists, Inc. to survey for unionids along the left descending bank of the Ohio River upstream and downstream of Greenup Locks and Dam. The objective of the study was to determine unionid species composition, relative abundance, and distribution within the study area.

Table 1-1. Recent unionid species records in the upper Ohio River.

| Species ¹ | Common Name | Status ² | ORM 0 to 418.9 ^{3,4} | Meldahl Pool ^{3,5} |
|-----------------------------------|------------------------|---------------------|-------------------------------|-----------------------------|
| <i>Actinonaias ligamentina</i> | mucket | | L | L |
| <i>Amblema p. plicata</i> | threeridge | | L | L |
| <i>Cyclonaias tuberculata</i> | purple wartyback | | L | L |
| <i>Cyprogenia stegaria</i> | fanshell | FE,KYE,OE | L | |
| <i>Ellipsaria lineolata</i> | butterfly | OE | L | L |
| <i>Elliptio crassidens</i> | elephant-ear | OE | L | L |
| <i>Elliptio dilatata</i> | spike | | L | L |
| <i>Epioblasma t. torulosa</i> | tubercled blossom | FE,KYE | SF | |
| <i>Epioblasma triquetra</i> | snuffbox | C2,KYS | FD | |
| <i>Fusconaia ebena</i> | ebonyshell | | L | L |
| <i>Fusconaia flava</i> | Wabash pigtoe | | L | L |
| <i>Fusconaia subrotunda</i> | long-solid | OE,KYT | L | L |
| <i>Lampsilis abrupta</i> | pink mucket | FE,KYE,OE | L | |
| <i>Lampsilis cardium</i> | plain pocketbook | | L | L |
| <i>Lampsilis ovata</i> | pocketbook | KYE,OE | L | L |
| <i>Lampsilis siliquoidea</i> | fatmucket | | L | L |
| <i>Lampsilis teres</i> | yellow sandshell | OE | L | L |
| <i>Lasmigona c. complanata</i> | white heelsplitter | | L | L |
| <i>Lasmigona costata</i> | fluted-shell | | L | |
| <i>Leptodea fragilis</i> | fragile papershell | | L | L |
| <i>Ligumia recta</i> | black sandshell | | L | L |
| <i>Megalonaias nervosa</i> | washboard | OE | L | L |
| <i>Obliquaria reflexa</i> | threehorn wartyback | | L | L |
| <i>Obovaria olivaria</i> | hickorynut | OE | SF | |
| <i>Obovaria retusa</i> | ring pink | FE,KYE | WD | SF |
| <i>Obovaria subrotunda</i> | round hickorynut | | L | |
| <i>Plethobasus cicatricosus</i> | white wartyback | FE | SF | |
| <i>Plethobasus cooperianus</i> | orange-foot pimpleback | FE,KYE,OE | WD | |
| <i>Plethobasus cyphus</i> | sheepnose | KYS,OE | L | L |
| <i>Pleurobema clava</i> | clubshell | FE,KYE,OE | SF | |
| <i>Pleurobema coccineum</i> | round pigtoe | | L | L |
| <i>Pleurobema cordatum</i> | Ohio pigtoe | OE | L | L |
| <i>Pleurobema plenum</i> | rough pigtoe | FE,KYE | SF | |
| <i>Pleurobema pyramidatum</i> | pyramid pigtoe | C2,KYE | SF | |
| <i>Potamilus alatus</i> | pink heelsplitter | | L | L |
| <i>Potamilus ohiensis</i> | pink papershell | | L | FD |
| <i>Ptychobranchus fasciolaris</i> | kidneyshell | | SF | |
| <i>Pyganodon grandis</i> | giant floater | | L | L |
| <i>Quadrula metanevra</i> | monkeyface | OE | L | L |
| <i>Quadrula nodulata</i> | wartyback | OE | L | L |
| <i>Quadrula p. pustulosa</i> | pimpleback | | L | L |
| <i>Quadrula quadrula</i> | mapleleaf | | L | L |
| <i>Simpsonaias ambiguia</i> | salamander mussel | C2,KYT | FD | |
| <i>Strophitus undulatus</i> | squawfoot | | L | |
| <i>Toxolasma parvus</i> | lilliput | | L | |
| <i>Tritogonia verrucosa</i> | pistolgrip | | L | L |
| <i>Truncilla donaciformis</i> | fawnsfoot | | L | L |
| <i>Truncilla truncata</i> | deertoe | | L | L |
| <i>Utterbackia imbecillis</i> | paper pondshell | | L | |
| <i>Uniomerus tetralasmus</i> | pondhorn | | L | |
| Total Species | | | 50 | 31 |
| Species Live (L and FD) | | | 41 | 30 |
| Species Weathered (WD and SF) | | | 9 | 1 |

¹Nomenclature follows Turgeon *et al.* (1988) and Hoeh (1990)²FE=Federally Endangered (USFWS, 1996); C2=Former category 2 species (USFWS, 1991); KYE=Kentucky Endangered, KYT=Kentucky Threatened, KYS=Kentucky Species of Special Concern (Kentucky State Nature Preserves Commission, 1994); OE=Ohio Endangered (ODNR, 1995)³Best Condition; L=Live, FD=Freshly Dead Shell, WD=Weathered Shell, SF=Subfossil Shell⁴Taylor (1980), Tolin and Schettig (1983), Zeto *et al.* (1987), ESE (1995), ESI (1990, 1991, 1993, 1994a, 1994b, 1995a, 1996a, 1996b, 1997, 1998a, 1998b, 1998c), Miller and Payne (1995), P. Morrison (pers. comm.), W. Tolin (pers. comm.)⁵ESI (1998c), P. Morrison (pers. comm.)

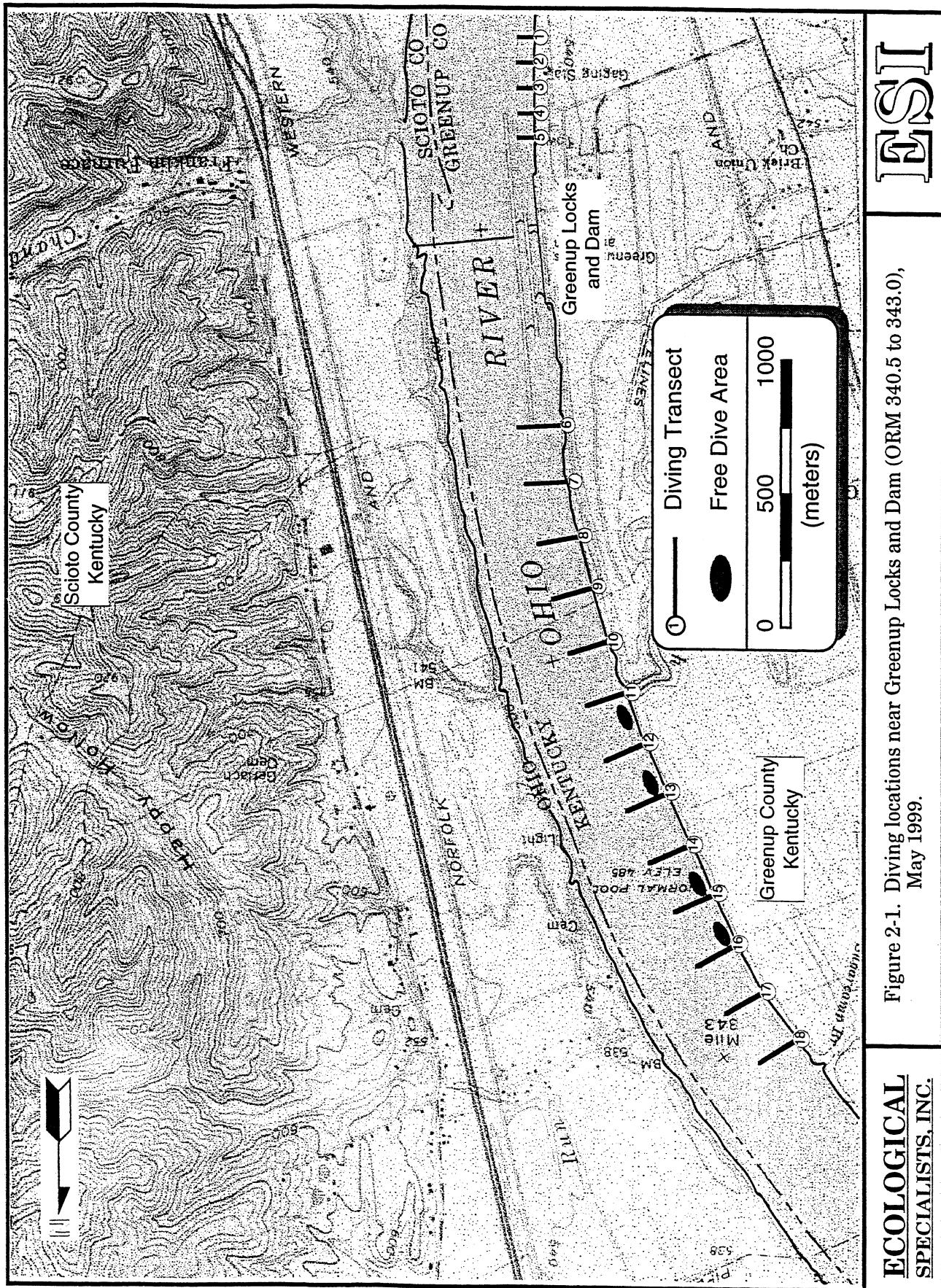
2.0 Methods

Unionids were sampled in the Ohio River upstream and downstream Greenup Locks and Dam (ORM 340.5 to 343.0) Greenup County, Kentucky, from 13 to 17 May 1999. The main objective of this study was to determine if Federally endangered species would be affected by this project. The effort required to find uncommon species is often considerable, and they are rarely collected in brail or quantitative samples (Kovalak *et al.*, 1986, Strayer *et al.*, 1997). Timed searches yield a better estimate of unionid species richness than quantitative samples (Strayer *et al.*, 1997; Vaughn *et al.*, 1997), as well as providing relative abundance per unit of effort. Semi-quantitative sampling (timed visual and tactful searches within a given area) are less time consuming and generally yield a greater number of unionids than quantitative samples, while providing a relative idea of unionid distribution (Dunn, in press). Therefore, semi-quantitative sampling was used to estimate species composition and distribution of the unionid community. Additional qualitative timed searches were conducted in areas of unionid concentrations to increase the probability of finding rare or endangered species.

Semi-quantitative sampling was conducted along transect lines laid perpendicular to the left descending riverbank (Figure 2-1). Upstream of Greenup Locks and Dam water depth exceeded safe limits (12m) beyond 50m of the riverbank. Therefore, transects were limited to 50m long, but were spaced 100m apart from ORM 340.5 to the lock wall (five transects). Downstream of Greenup Locks and Dam, 13, 150m long transects spaced 200m apart were established perpendicular to the bank between the downstream end of the lock wall and ORM 343.0. No sampling was conducted within the restricted area of the dam (see Figure 2-1). Transects were marked at 10m intervals, and a 1m corridor within each interval (1 x 10m) was searched visually and tactually for four minutes and treated as a separate sample. General substrate composition was visually characterized by the diver in each interval and relayed to the surface crew.

To better characterize the unionid community, additional qualitative sampling was conducted in areas of unionid concentrations (between 10 and 30m from the bank and between Transects 11 and 16) until 1000 or more live unionids were collected. Additionally, the entire shoreline from Transect 11 to 18 was searched for shells.

All live unionids were identified, measured (length in mm), aged (external annuli count), and weighed (grams). Empty shells were also collected, identified, and categorized as freshly dead (nacre still lustrous, probably died within the last year), weathered (nacre chalky, probably dead more than a few months), or subfossil (periostracum eroded or shell fragmented, probably dead >10 years).



3.0 Results and Discussion

3.1 Habitat Characteristics and Sampling Conditions

Habitat differed considerably upstream and downstream of the locks and dam. Upstream, current velocity was <0.1 knots, and water depth averaged 5m within 50m of the bank, but was >12m at 50m. Substrate consisted primarily of fine depositional sediment (Table 3-1).

Downstream of the lock, water was shallower, averaging 2.8m (range 1.2 to 4.0m) within 50m of the bank, and 3.6m (range 1.2 to 4.9m) between the bank and 150m. Current velocity ranged from 0.5 knots near the lock to 2.2 knots downstream of Transect 10. Substrate was coarser downstream of the dam due to increased flow. However substrate characteristics varied with distance from the lock and distance from the bank. Substrate was more heterogeneous within 50m of the bank, and contained finer sediment and wood debris, particularly along Transects 6 to 10. Substrate was primarily cobble, gravel, and sand between 50 to 100m. Beyond 100m substrate was less hospitable as bedrock, boulder, and large cobble were prevalent. Additionally, several mounds of gravel were noted between Transects 13 and 18 that appeared to be a result of previous dredging activity. However, divers did not note obvious recent disturbances to the substrate within this area.

3.2 Unionid Fauna

A diverse and reproducing unionid bed is present within the study area, however unionids were primarily collected within 50m of the bank and downstream of Transect 11 (Table 3-2). No live individuals or shells were collected along Transects 1 to 5 upstream of the dam. This is likely due to the fine sediment and lack of flow associated with impoundment (Bates, 1962; Suloway *et al.*, 1981; ESI, 1995b).

Unionids were also absent downstream of the dam from Transects 6 to 8, and only one individual was collected between Transects 9 and 10 (see Table 3-2). The lack of unionids immediately downstream of the lock may be due to disturbance from towboat and barge activity. Miller and Payne's (1998) study suggest no measurable effects of commercial traffic on unionids, however they indicate that effects are dependent on vessel size, substrate, and depth and that each situation should be evaluated independently. Alternatively, the lack of unionids in this area could be due to hydrology which affects substrate characteristics. During low flow, most of the discharge from the dam is through the hydropower turbines located near the Ohio bank. Flow out of the turbines appears to be directed at an angle toward the Kentucky bank, increasing current velocity downstream of Transect 10. Flow immediately downstream of the lock on the other hand is primarily a result of released lock water, and current velocity is much slower.

A unionid bed appears to begin near ORM 342.0, and nearly all live individuals were collected between

Table 3-1. Habitat characteristics along transects on the Ohio River near Greenup Locks and Dam (ORM 342.5 to 343.0) May, 1999.

| Transect | Distance from Bank (m) | | | | | | Date | Temp. (C°) | Dissolved Oxygen (ppm) | Secchi (mm) | | | | |
|----------|--|-----------|-------------------------|-----------|--------------------------------|-----------|---------|------------|------------------------|-------------|--|--|--|--|
| | 0-50 | | 50-100 | | 100-150 | | | | | | | | | |
| | Substrate | Depth (m) | Substrate | Depth (m) | Substrate | Depth (m) | | | | | | | | |
| 1 | mud/cobble/gravel | 5.0 | | | | | 5/13/99 | 20.5 | 8.8 | 1500 | | | | |
| 2 | mud | 5.0 | | | | | 5/13/99 | 20.5 | 8.8 | 1500 | | | | |
| 3 | mud | 5.0 | | | | | 5/13/99 | 20.5 | 8.8 | 1500 | | | | |
| 4 | mud | 5.0 | | | | | 5/13/99 | 20.5 | 8.8 | 1500 | | | | |
| 5 | mud | 5.0 | | | | | 5/13/99 | 20.5 | 8.8 | 1500 | | | | |
| 6 | bedrock/sand/mud | 4.0 | bedrock/gravel/sand | 4.5 | bedrock/cobble/sand | 4.3 | 5/13/99 | 20.5 | 8.8 | 1500 | | | | |
| 7 | cobble/gravel/sand | 3.7 | bedrock/cobble/sand | 4.6 | bedrock/cobble/gravel/sand | 4.3 | 5/13/99 | 20.5 | 8.8 | 1500 | | | | |
| 8 | cobble/gravel/sand/wood debris | 3.1 | gravel/sand | 4.5 | bedrock/cobble/sand | 4.7 | 5/13/99 | 20.5 | 8.8 | 1500 | | | | |
| 9 | boulder/gravel/sand/wood debris | 3.7 | cobble/gravel/sand | 4.3 | cobble/gravel/sand | 4.7 | 5/14/99 | 20.0 | 9.0 | 1000 | | | | |
| 10 | gravel/sand/silt/cobble/sand/zebra mussels | 2.7 | cobble/sand | 4.3 | cobble/sand | 4.6 | 5/14/99 | 20.0 | 9.0 | 1000 | | | | |
| 11 | cobble/sand/zebra mussels | 2.8 | cobble/sand | 4.0 | cobble/sand | 4.7 | 5/14/99 | 20.0 | 9.0 | 1000 | | | | |
| 12 | cobble/sand/silt/zebra mussels | 3.2 | cobble/sand | 4.1 | cobble/sand | 4.3 | 5/14/99 | 20.0 | 9.0 | 1000 | | | | |
| 13 | cobble/sand/silt/zebra mussels | 2.6 | cobble/sand | 4.5 | bedrock/boulder/sand | 4.9 | 5/14/99 | 20.0 | 9.0 | 1000 | | | | |
| 14 | sand/silt/wood debris | 1.6 | cobble/sand | 3.7 | bedrock/boulder/sand | 4.4 | 5/15/99 | 20.0 | 9.1 | 1500 | | | | |
| 15 | cobble/sand/silt/zebra mussels | 2.2 | cobble/sand | 4.3 | cobble/sand | 4.7 | 5/15/99 | 20.0 | 9.1 | 1500 | | | | |
| 16 | cobble/gravel/sand/zebra mussels | 2.6 | cobble/gravel/sand | 4.3 | boulder/gravel/sand | 4.9 | 5/15/99 | 20.0 | 9.1 | 1500 | | | | |
| 17 | cobble/gravel/sand/zebra mussels | 3.2 | cobble/gravel/sand | 4.5 | cobble/sand | 4.7 | 5/16/99 | 20.0 | 9.1 | 1800 | | | | |
| 18 | cobble/gravel/sand/silt/zebra mussels | 1.2 | cobble/gravel/sand/clay | 3.3 | cobble/gravel/sand/wood debris | 4.7 | 5/16/99 | 20.0 | 9.1 | 1800 | | | | |

Table 3.2. Unionid abundance along transects near Greenup Locks and Dam (ORM 340.5 to 343.0), May 1999.

| Species | Transect | | | | | | | | | | | | | | | Total | | | | |
|--|----------|-----|-----|-----|-----|-----|-----|-----|------|-----|------|-----|-----|------|-----|-------|-----|-----|------|-----|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | | |
| <i>Ambloema p. plicata</i> | SF | | | | | | | | 1 | 5 | 1 | | | 2 | FD | 2 | 3 | 14 | | |
| <i>Ellipsaria lineolata</i> | | | | | | | | | 1 | 2 | | | | 2 | 1 | 1 | 6 | 6 | | |
| <i>Elliptio crassidens</i> | | | | | | | | | | | | | | | WD | | WD | | | |
| <i>Lampsilis cardium</i> | | 1 | | | | | | | WD | | 1 | | | | 1 | | 3 | 6 | | |
| <i>Ligumia recta</i> | | | | | | | | | 1 | | WD | 1 | | 2 | | 4 | 4 | 8 | | |
| <i>Obliquaria reflexa</i> | | | | | | | | | WD | 1 | 10 | 3 | 1 | 15 | FD | 1 | 6 | 37 | | |
| <i>Potamilus alatus</i> | WD | | | | | | | | WD | WD | FD | 1 | 1 | WD | WD | 1 | 2 | 5 | | |
| <i>Quadrula metanevra</i> | | | | | | | | | 2 | 7 | 5 | 1 | 6 | | | 2 | 1 | 24 | | |
| <i>Quadrula p. pustulosa</i> | | | | | | | | | WD | FD | 1 | 4 | 2 | | | 2 | 2 | 11 | | |
| <i>Quadrula quadrula</i> | | | | | | | | | | | | 1 | 1 | | | 2 | 4 | | | |
| <i>Truncilla truncata</i> | | | | | | | | | | | | WD | 1 | | | 1 | | | | |
| Total | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 6 | 29 | 16 | 4 | 27 | 4 | 8 | 21 | 116 |
| No. live species | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 5 | 7 | 8 | 4 | 5 | 3 | 5 | 7 | 10 |
| Total species | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 2 | 7 | 8 | 9 | 5 | 6 | 6 | 5 | 11 |
| CPUE (No./10min) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 1.0 | 4.8 | 2.7 | 0.7 | 4.5 | 0.7 | 1.3 | 3.5 | 1.1 |
| Density (No./m ²) ¹ | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | <0.1 | 0.0 | <0.1 | 0.2 | 0.1 | <0.1 | 0.2 | <0.1 | 0.1 | 0.1 | <0.1 | |

¹Approximate density based on 151x10m qualitative samples per transect

Transects 11 and 18 and within 50m of the bank (see Figure 2-1 and Table 3-2). A total of 112 of the 116 live unionids of 10 species collected in semi-quantitative samples were found within 50m of the bank between Transects 11 to 18. CPUE in this area averaged 7.0 unionids/10min and density averaged 2.8 unionids/m² (Table 3-3). An additional 1,114 live unionids of 17 species were collected during qualitative searches between 20 and 50m from the bank and between Transects 11 and 16.

The location of this unionid bed with respect to the dam and the bank is probably due to higher current velocity downstream of Transect 10, as a result of hydropower release, and the greater heterogeneity of substrate composition and less coarse sediment near the bank (see Table 3-1). Unionids are usually more abundant near the bank in large rivers than in the river channel (Way *et al.*, 1989; Miller and Payne, 1993; ESI, 1994c). Additionally, unionid beds are usually found in areas of stable sand, gravel, and cobble substrate which is typically indicative of suitable unionid habitat (Strayer and Ralley, 1991; Vaughn, 1997). The greater amount of sedimentary material near the bank, and a preponderance of bedrock near the channel suggest substrate was more suitable for unionids near the bank. This was also the area zebra mussels (*Dreissena polymorpha*) were most abundant, and divers noted a positive relationship between the distribution of unionids and zebra mussels. Unionids were rarely found in areas without zebra mussels.

No live Federally listed species were collected, however, a subfossil shell of the Federally endangered *Obovaria retusa* was collected during the bank search. Several live species listed as endangered in Ohio or Kentucky were also collected (*Ellipsaria lineolata*, *Lampsilis ovata*, *Megalonaia nervosa*, *Plethobasus cyphyus*, *Pleurobema cordatum*, and *Quadrula nodulata*). *Obliquaria reflexa* (34.6%), *Quadrula p. pustulosa* (15.8%), *Quadrula metanevra* (15.1%), and *Amblema p. plicata* (11.5%) dominated the community (Table 3-4). *Ellipsaria lineolata* (6.8%), *Quadrula quadrula* (5.1%), *Ligumia recta* (3.7%), *Lampsilis cardium* (3.6%), and *Potamilus alatus* (2.1%) were also relatively common, while the remaining species comprised less than 1% of the community. Species collected in this study which are relatively uncommon in the upper Ohio River include *Elliptio dilatata*, *L. ovata*, *P. cyphyus*, and *Q. nodulata*. Whereas, species which are usually found in the upper Ohio River that were absent in this study included *Fusconaia flava*, *Leptodea fragilis*, and *Lasmigona c. complanata*.

The methods used in this study (semi-quantitative and qualitative) are typically biased toward larger animals and juveniles are generally under represented in samples (Payne *et al.*, 1997; Vaughn *et al.*, 1997). Juvenile unionids were not common in this study (7.6% of individuals were ≤5 years old), however juveniles ≤3 years old and ≤5 years old were collected for 33.3% and 66.7% of the live species collected, respectively (Table 3-4); indicating that successful recruitment is occurring for most species.

Table 3-3. Comparison of unionid abundance and distribution along Transects 11 to 18.

| Species | 0 to 50 Meters ¹ | | 50 to 100 Meters | | 100 to 150 Meters | | Total | |
|--|-----------------------------|----------------|------------------|----------------|-------------------|----------------|-------|----------------|
| | (n) | % (No./10min.) | (n) | % (No./10min.) | (n) | % (No./10min.) | (n) | % (No./10min.) |
| <i>Ambloema p. plicata</i> | 14 | 12.5 | 0.9 | | | | 14 | 12.2 |
| <i>Ellipsaria lineolata</i> | 6 | 5.4 | 0.4 | | | | 6 | 5.2 |
| <i>Elliptio crassidens</i> | | | | WD | | | WD | 0.1 |
| <i>Lampsilis cardium</i> | 5 | 4.5 | 0.3 | 1 | 33.3 | 0.1 | | |
| <i>Ligumia recta</i> | 7 | 6.3 | 0.4 | | | | 7 | 6.1 |
| <i>Obliquaria reflexa</i> | 36 | 32.1 | 2.3 | 1 | 33.3 | 0.1 | 37 | 32.2 |
| <i>Potamilus alatus</i> | 5 | 4.5 | 0.3 | WD | | | 5 | 4.3 |
| ♀ <i>Quadrula metaneura</i> | 23 | 20.5 | 1.4 | 1 | 33.3 | 0.1 | 24 | 20.9 |
| <i>Quadrula p. pustulosa</i> | 11 | 9.8 | 0.7 | | | | 11 | 9.6 |
| <i>Quadrula quadrula</i> | 4 | 3.6 | 0.3 | | | | 4 | 3.5 |
| <i>Truncilla truncata</i> | 1 | 0.9 | 0.1 | WD | | | 1 | 0.9 |
| Total | 112 | | 3 | | 0 | | 115 | |
| No. live species | 10 | | 3 | | 0 | | 10 | |
| Total species | 10 | | 6 | | 0 | | 11 | |
| CPUE (No./10min.) | | 7.0 | | 0.2 | | 0.0 | 0.0 | 1.9 |
| Density (No./m ²) ² | 2.8 | | 0.1 | | 0.0 | | 0.8 | |

¹Distance from Kentucky bank²Approximate density based on 50, 1x10m semi-quantitative samples along Transects 11 to 18

Table 3-4. Unionid relative abundance and community characteristics near Greenup Locks and Dam¹ (ORM 340.5 to 342.0), May 1999.

| Species | No. ² | % ³ | Age (years) | | | Length (mm) | | | Weight (g) | | |
|--------------------------------|------------------|----------------|-------------|------|------|-------------|------|------|------------|------|------|
| | | | Ave. | Min. | Max. | Ave. | Min. | Max. | Ave. | Min. | Max. |
| <i>Actinonaias ligamentina</i> | WD | | | | | 73.7 | 25 | 113 | 136.0 | 8 | 335 |
| <i>Ambloema p. plicata</i> | 142 | 11.5 | 8.7 | 3 | 16 | 55.4 | 14 | 88 | 60.9 | 12 | 226 |
| <i>Ellipsaria lineolata</i> | 84 | 6.8 | 6.5 | 3 | 15 | | | | | | |
| <i>Elliptio crassidens</i> | WD | | | | | | | | | | |
| <i>Elliptio dilatata</i> | 1 | 0.1 | 11.0 | 11 | 11 | 96.0 | 96 | 96 | 102.0 | 102 | 102 |
| <i>Fusconaia ebena</i> | 1 | 0.1 | 5.0 | 5 | 5 | 38.0 | 38 | 38 | 32.0 | 32 | 32 |
| <i>Fusconaia flava</i> | WD | | | | | | | | | | |
| <i>Lampsilis cardium</i> | 44 | 3.6 | 10.2 | 4 | 20 | 102.4 | 70 | 128 | 259.4 | 75 | 480 |
| <i>Lampsilis ovata</i> | 3 | 0.2 | 11.0 | 9 | 13 | 108.7 | 105 | 116 | 301.0 | 224 | 364 |
| <i>Lampsilis stilioides</i> | 1 | 0.1 | 6.0 | 6 | 6 | 90.0 | 90 | 90 | 110.0 | 110 | 110 |
| <i>Leptodea fragilis</i> | WD | | | | | | | | | | |
| <i>Ligumia recta</i> | 45 | 3.7 | 7.4 | 4 | 12 | 124.4 | 79 | 154 | 184.9 | 56 | 362 |
| <i>Megalonaia nervosa</i> | 7 | 0.6 | 9.7 | 7 | 11 | 111.9 | 83 | 124 | 273.6 | 130 | 375 |
| <i>Obliquaria reflexa</i> | 426 | 34.6 | 6.1 | 3 | 12 | 42.4 | 24 | 57 | 37.5 | 2 | 84 |
| <i>Obovaria retusa</i> | SF | | | | | | | | | | |
| <i>Plethobasius cyphyus</i> | 2 | 0.2 | 9.5 | 5 | 14 | 84.0 | 60 | 108 | 190.0 | 72 | 308 |
| <i>Pleurobema cordatum</i> | 3 | 0.2 | 12.7 | 12 | 14 | 68.3 | 58 | 74 | 148.7 | 110 | 192 |
| <i>Potamilus alatus</i> | 26 | 2.1 | 6.7 | 4 | 9 | 99.2 | 56 | 120 | 105.1 | 18 | 186 |
| <i>Quadrula metanevra</i> | 186 | 15.1 | 9.0 | 4 | 15 | 62.3 | 33 | 80 | 99.4 | 14 | 204 |
| <i>Quadrula nodulata</i> | 1 | 0.1 | 7.0 | 7 | 7 | 56.0 | 56 | 56 | 98.0 | 98 | 98 |
| <i>Quadrula p. pustulosa</i> | 194 | 15.8 | 8.7 | 3 | 15 | 46.5 | 23 | 68 | 56.3 | 12 | 100 |
| <i>Quadrula quadrula</i> | 63 | 5.1 | 9.5 | 3 | 16 | 63.4 | 28 | 79 | 90.4 | 6 | 150 |
| <i>Truncilla donaciformis</i> | WD | | | | | | | | | | |
| <i>Truncilla truncata</i> | 1 | 0.1 | 3.0 | 3 | 3 | 25.0 | 25 | 25 | 5.0 | 5 | 5 |
| Total | 1,230 | | | | | | | | 113.9 | 2 | 480 |
| Live species | 18 | | | | | | | | | | |
| Total species | 24 | | | | | | | | | | |
| % ≤3 years | | | | | | | | | 0.1 | | |
| % ≤5 years | | | | | | | | | 7.6 | | |

¹Based on qualitative sampling along transects, free dives, and bank searches.

²Best condition reported; WD=weathered shell, SF=sub-fossil specimen.

4.0 Conclusions and Recommendations

Unionids have colonized the downstream reach of the study area, as a low density unionid community was found between Transects 11 and 18. This appears to be a newly colonizing bed. Although density appears to be low, species richness was high (18 species), recent recruitment is apparent, and maximum age was only 20 years old. No Federally endangered species were collected. However, Federally endangered species have been collected in other upper Ohio River beds (ESI, 1998a) with similar characteristics (low density, high species richness, and evidence of reproduction) and several species that are rare in the upper Ohio River and/or are protected by Kentucky and/or Ohio were found. Federally endangered species may be present, but in a very low frequency (<0.1% of the community).

This unionid bed will probably not be affected by this project since it is located at least 2,000m downstream of the lock. However, this bed should be considered in project planning.

The fact that such a diverse community inhabits the inside bend of this river reach suggests that the right descending bank may harbor an even better community, as is the case downstream of Belleville Locks and Dam (ESI, 1998a). Outside bends have more consistent flow, are less depositional than inside bends, and are often more conducive to unionid communities (ESI, 1997). Williams and Schuster (1989) found nine unionid species while brailing between ORM 342.0 and 343.5 along the Ohio bank even though their sampling method was fairly inefficient. The Ohio side of the river may harbor a higher density and species rich unionid community than the study area and future study in this river reach is warranted.

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APPENDIX C

**BHE ENVIRONMENTAL, INC. -
INDIANA BAT SURVEY**

1086.01

21 May 1999

**MIST NET SURVEY FOR THE INDIANA BAT
ALONG THE PROPOSED GREENUP DAM
EXPANSION IN GREENUP COUNTY, KENTUCKY**

Submitted to:

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Table of Contents

| | <u>Page</u> |
|---|-------------|
| SECTION 1.0: INTRODUCTION | 1 |
| SECTION 2.0: NATURAL HISTORY OF THE INDIANA BAT | 3 |
| SECTION 3.0: METHODS | 5 |
| 3.1 BAT CAPTURE | 5 |
| 3.2 HABITAT ASSESSMENT | 5 |
| SECTION 4.0: RESULTS | 7 |
| 4.1 BAT CAPTURE | 7 |
| 4.2 HABITAT ASSESSMENT | 7 |
| SECTION 5.0: DISCUSSION | 9 |
| SECTION 6.0: LITERATURE CITED..... | 10 |
| APPENDIX A: PHOTOGRAPHS | 11 |

Figures

| | <u>Page</u> |
|--|-------------|
| 1. Location of proposed Greenup Locks & Dam Facility expansion area (Wheelersburg OH-KY quadrangle). | 2 |
| 2. Range of the Indiana bat in the United States | 4 |
| 3. Location of mist net sites within the proposed project area (Wheelersburg OH- KY quadrangle | 6 |

Tables

| | <u>Page</u> |
|---|-------------|
| 1. Bats captured within the proposed Greenup Locks & Dam Facility expansion area during 15-16 May 1999..... | 7 |
| 2. Characteristics of habitat near mist net sites | 8 |

Section 1.0: Introduction

As part of the proposed Ohio River Main Stem System Study, the U.S. Army Corps of Engineers, Huntington District proposes to expand the Greenup Locks & Dam facility. The proposed expansion area covers approximately 160 acres along the Ohio River in Greenup County, Kentucky (Figure 1). The U.S. Fish and Wildlife Service (FWS) indicates the endangered Indiana bat (*Myotis sodalis*) may be present within the proposed project site. A preliminary site visit indicated potential roost habitat for Indiana bats occurs within the proposed project area (pers. comm. Ken Lammers). If Indiana bats are present, clearing trees within the proposed project area while the species occupies summer habitat (15 April–15 September) may affect Indiana bats.

BHE Environmental, Inc. (BHE) was retained to survey for the Indiana bat within the proposed project area. BHE conducted a mist net survey and determined habitat suitability for Indiana bats within the proposed project area.

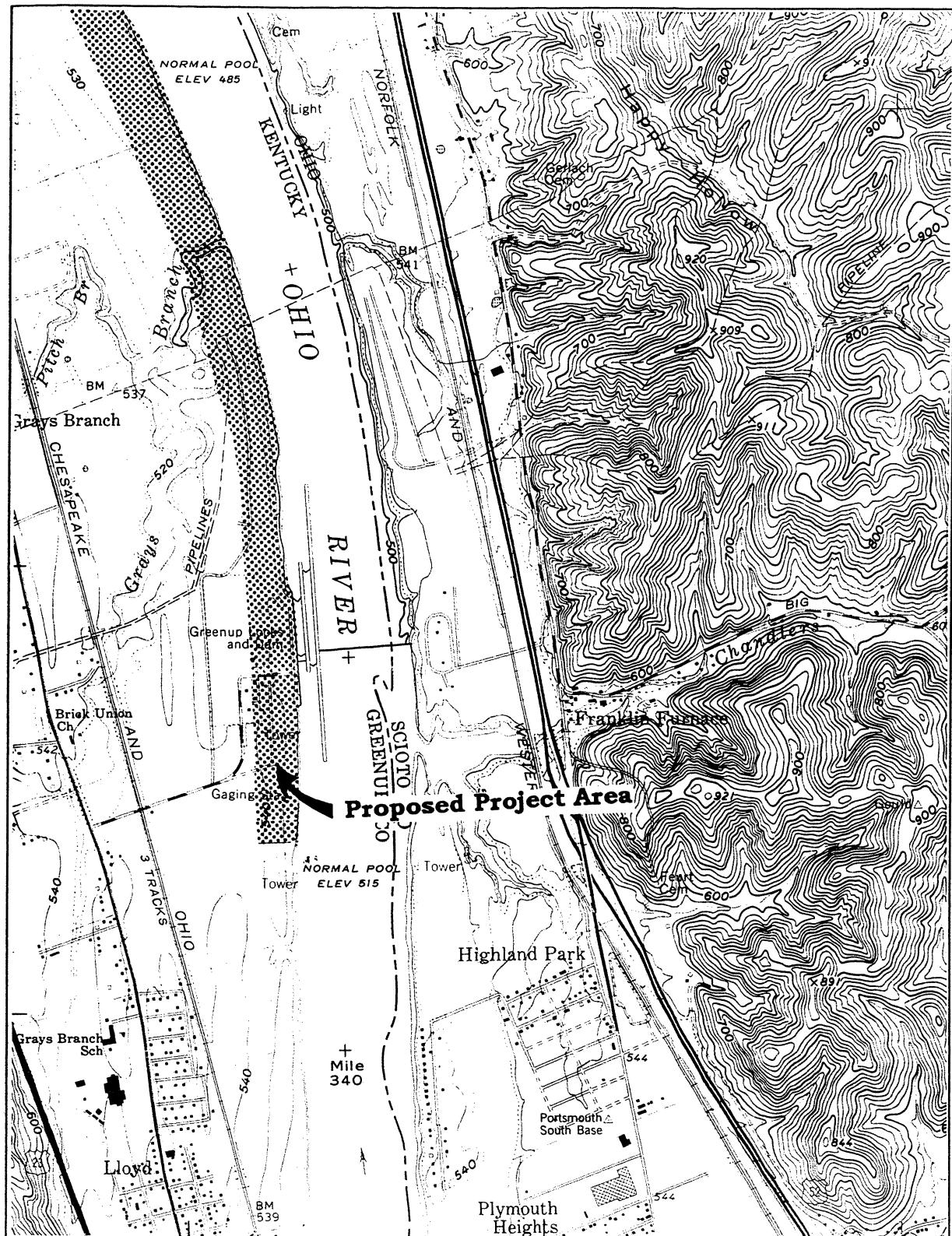


FIGURE 1. Location of proposed Greenup Locks & Dam Facility expansion area (Wheelersburg OH-KY quadrangle).

Section 2.0: Natural History of the Indiana Bat

The Indiana bat is found throughout the eastern United States, from Oklahoma, Iowa, and Wisconsin east to Vermont, and south to northwestern Florida (Barbour and Davis 1969). The species is migratory, and this range includes both summer and winter habitat. The winter range is associated with regions of karst topography, primarily Indiana, Kentucky, and Missouri. The majority of summer occurrences are primarily from the glaciated portions of the midwest U.S. (southern Iowa and Michigan; northern Missouri, Illinois, and Indiana; and western Ohio). However, data on summer distribution may reflect lack of search effort in some areas (FWS 1999). Summer occurrences of Indiana bats are known from 29 counties throughout Kentucky (Figure 2; FWS 1999).

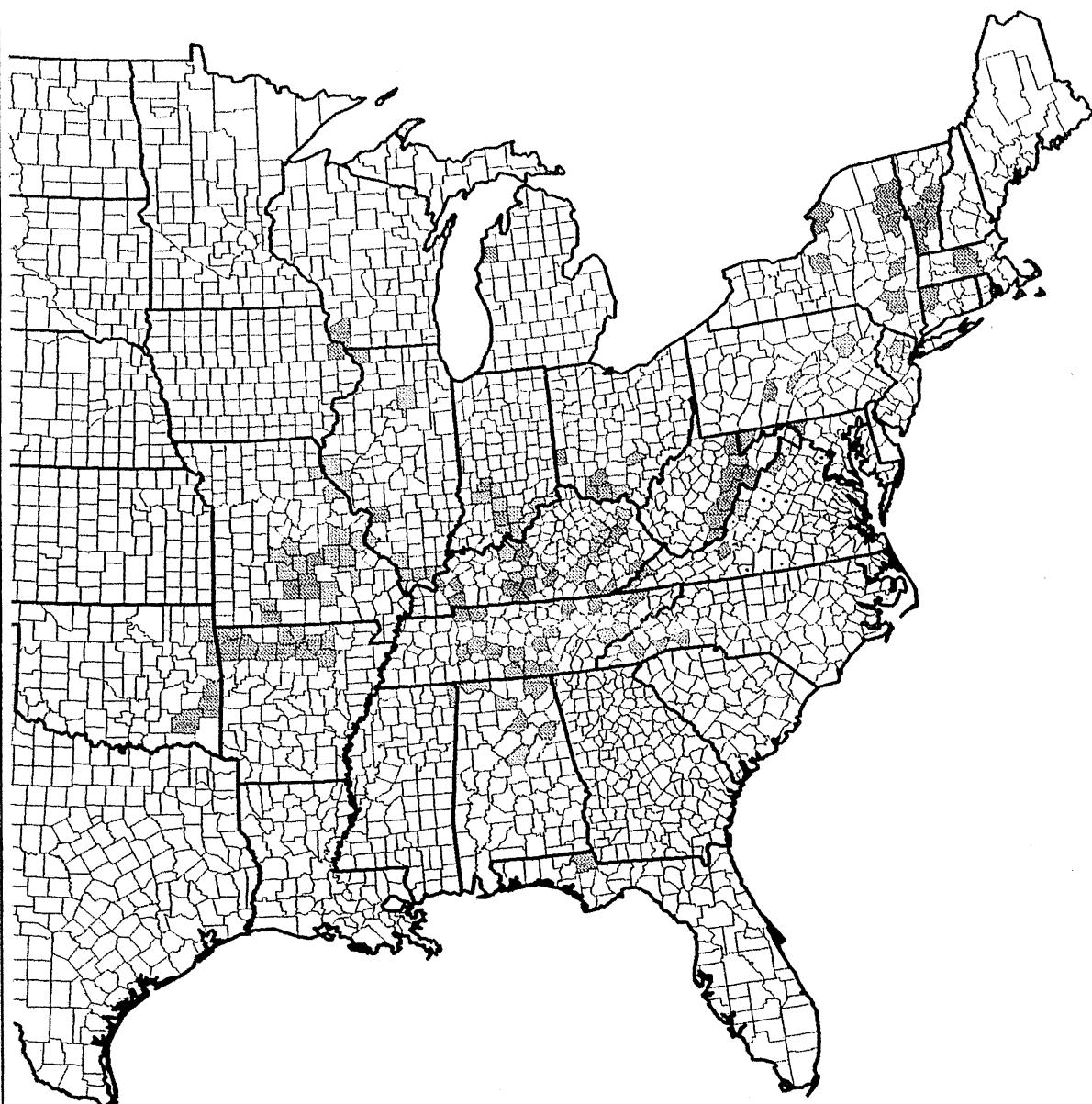
In summer, Indiana bats migrate to forested bottomlands, uplands, and riparian habitats. This species roosts under exfoliating bark or in cavities of trees. Reproductive females form maternity colonies that may consist of up to 100 adult female bats (FWS 1999). Male Indiana bats tend to roost singly or in small groups (FWS 1999). Males may occur anywhere throughout the range of the species, including near hibernacula.

Indiana bats forage most frequently in upland and riparian forests, but they also may forage along wooded edges between forests and croplands, and over fallow fields (Brack 1983, LaVal and LaVal, 1980). They frequently use open space over streams as travel corridors.

Indiana bats were listed by the federal government as endangered on 11 March 1967. Populations across the species range (as recorded from counts in hibernacula) have declined since the late 1950s. A principle cause of decline is destruction of hibernacula from collapse, flooding, or vandalism by humans. Suspected contributing factors include loss of suitable summer habitat, and contamination by pesticides (FWS 1999).

Between 1960 and 1975, Indiana bat populations in Kentucky declined by an estimated 145,000 bats. During the past 15 years, populations in west-central, northeastern, and extreme southeastern Kentucky have declined, while populations in east-central and western parts of the state have increased (FWS 1999). The total known population of Indiana bats continues to decline (FWS 1999).

A recovery plan for Indiana bats was developed by a FWS-sponsored recovery team in 1983 (FWS 1983). The team currently is revising the plan to include updated information on Indiana bat ecology, and to highlight the continued and accelerated decline of the Indiana bat (FWS 1999). Briefly, objectives of the Indiana bat recovery plan include: (1) protect hibernacula, (2) maintain, protect, and restore summer maternity habitat, (3) monitor population trends through winter censusing, (4) educate the public, and (5) continue research. Maintenance, protection, and restoration of summer habitat (including maternity roost sites and foraging habitat) are now recovery priorities.



- County with Indiana bat summer record
- County with Indiana bat hibernacula
- County with Indiana bat hibernacula and Indiana bat summer record

Data courtesy of the Indiana bat recovery team and BHE Environmental, Inc.

FIGURE 2. Range of the Indiana bat in the United States.

Section 3.0: Methods

3.1 BAT CAPTURE

During 15-16 May 1999, BHE conducted a mist net survey in the proposed project area (Figure 1). Based on habitat characteristics and coordination with the FWS, Cookeville Field Office (pers. comm., Jim Widlak), two mist net sites were established within proposed project boundaries (Figure 3; Appendix A). Mist net site selection was based upon extent of canopy cover, presence of an open flyway, and forest conditions near the site.

The mist net survey was conducted according to guidelines developed by the Indiana bat recovery team (March 1999). At each site, two mist nets were deployed for two nights, for a total of four net-nights per site (a net-night equals one net deployed for one night). During the survey, a total of 8 net-nights were completed.

Mist nets were constructed of black nylon or monofilament nets with 1.5-inch mesh and frames similar to those described by Gardner et al. (1989). Mist nets were placed along forest corridors likely provide an open flyway for bats. Nets were 20 feet tall and 30-45 feet wide, depending upon the width of the corridor. When possible, nets were bounded by vegetation above and on both sides to facilitate capturing bats.

Mist nets were deployed at dusk (2040-2115 h) and monitored every 20 minutes until at least 0200 h. Disturbance near nets between checks was minimized. Following capture, we recorded species, capture location, age, sex, reproductive condition, right forearm length, and weight for each bat.

Weather conditions were documented each night to confirm netting was conducted in accordance with mist netting guidelines. Each hour, we recorded air temperature, wind speed, cloud cover, precipitation, and visibility of the moon. A standard mercury thermometer was used to record temperature, and wind speed and percent cloud cover were estimated.

3.2 HABITAT ASSESSMENT

Habitat near mist net sites was characterized to determine potential suitability for bats. The following habitat characteristics were recorded at each mist net site:

- Species list of dominant canopy, understory, and herbaceous vegetation
- Estimate of the average forest canopy closure over nets
- Estimate of the average size of canopy, understory, and herbaceous stems
- Other conditions pertinent to the quality of Indiana bat habitat

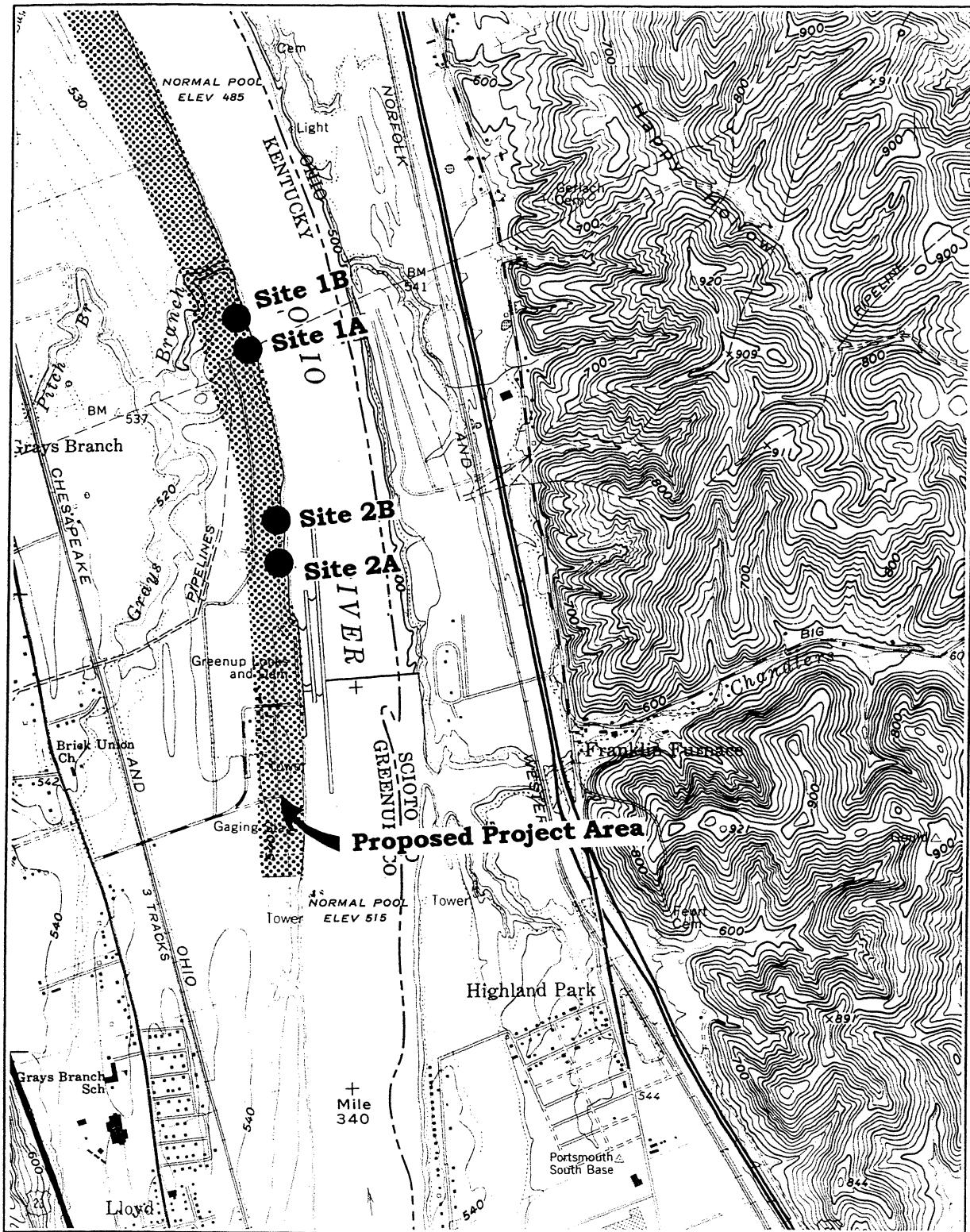


FIGURE 3. Location of mist net sites within the proposed project area (Wheelersburg OH-KY quadrangle.)

Section 4.0: Results

4.1 BAT CAPTURE

During 15-16 May 1999, 3 big brown bats (*Eptesicus fuscus*) were trapped within the proposed project area (Table 1). Two of the bats captured were pregnant females; one bat escaped before gender and reproductive condition was determined. No Indiana bats were captured during the survey. No federally- or state-listed species of bats were captured. Bats were captured at one (Site 1b) of four sites. No bats were captured at sites 1a, 2a, and 2b.

TABLE 1. Bats captured within the proposed Greenup Locks & Dam Facility expansion area during 15-16 May 1999.

| Site No. | Date (1999) | Common | | |
|-------------|----------------|-------------------------|---------------|-----------------|
| | | Species | Name | Description |
| 1b | 15 May | <i>Eptesicus fuscus</i> | Big brown bat | Escaped |
| 1b | 16 May | <i>Eptesicus fuscus</i> | Big brown bat | Pregnant female |
| 1b | 16 May | <i>Eptesicus fuscus</i> | Big brown bat | Pregnant female |

During mist net surveys, weather was mild and within guidelines of the Indiana bat recovery team. Air temperatures ranged from 51°F to 76°F. No precipitation occurred during the survey.

4.2 HABITAT ASSESSMENT

BHE documented habitat characteristics within the proposed project area (Table 2). Approximately half (80 acres) of the 160-acre area is forested. Non-forested portions include paved industrial areas, mowed pasture, and old field habitat (Appendix A). Human disturbance (e.g., mowing, roads, trails, past logging activity) is evident throughout the project area.

Forest within the project area consists primarily of trees with diameter at breast height (dbh) less than 10 inches. Near mist net sites 1a and 1b, 99 percent of trees are silver maple (*Acer saccharinum*), which form a relatively even-age stand. Silver maple and cottonwood (*Populus deltoides*) with dbh greater than 12 inches are scattered throughout the forested area. Overstory trees provide at least 85% canopy closure. Understory vegetation typically is dense, except on vehicle trails. Poison ivy vines cover many of the trees near mist net sites.

One perennial stream, Gray's Branch, flows through the project area. The stream is approximately 12-18 inches wide. Stream banks are up to 40-feet in height and are steeply sloped. The stream channel is partially blocked with debris and overhanging vegetation. Along the banks of Gray's Branch are large trees with dbh up to 4 feet.

TABLE 2. Characteristics of habitat near mist net sites.

| | Mist Net Site 1 | Mist Net Site 2 |
|----------------------------|---|---|
| Dominant Canopy Trees | Silver maple (A few sycamore, black locust, tree of heaven, and black willow exist along the edges of the site). | Cottonwood Box elder Sycamore Black locust |
| Estimated Canopy Closure | 90 % | 85 % |
| Average Canopy DBH | 10 inches | 12 inches |
| Dominant Understory Trees | Silver maple American elm Hackberry | Box elder Black cherry American elm |
| Average Understory DBH | 2 inches | 2 inches |
| Dominant Herbaceous Plants | Poison ivy Multiflora rose Goldenrod Elderberry | Poison ivy Multiflora rose Honeysuckle |

Section 5.0: Discussion

BHE conducted a mist net survey with the level of effort recommended by the FWS Cookeville Field Office and the Indiana Bat Recovery Team for assessing the presence/absence of Indiana bats. No Indiana bats were captured during the survey. Therefore, presence of Indiana bats within the project area was not confirmed.

The proposed project area appears to provide low to moderate quality habitat for Indiana bats. Within the forested area, trees primarily are less than 10 inches dbh with a limited number of larger trees. Suitable roosting habitat for Indiana bats appears to be limited although the large cottonwoods provide some potential roost sites. The silver maple trees have little exfoliating bark and generally do not provide potential roost sites for Indiana bats. Dense poison ivy vines growing on many of the trees may reduce potential for suitable roost sites for Indiana bats. Non-forested areas within the proposed project area do not provide suitable habitat for roosting Indiana bats.

This mist net survey did not confirm presence of Indiana bats within the proposed project area. However, survey results are not valid indefinitely. Changes in habitat characteristics may change habitat suitability for Indiana bats. The FWS may request additional Indiana bat surveys if forest within the project area is not cleared within 1–2 years.

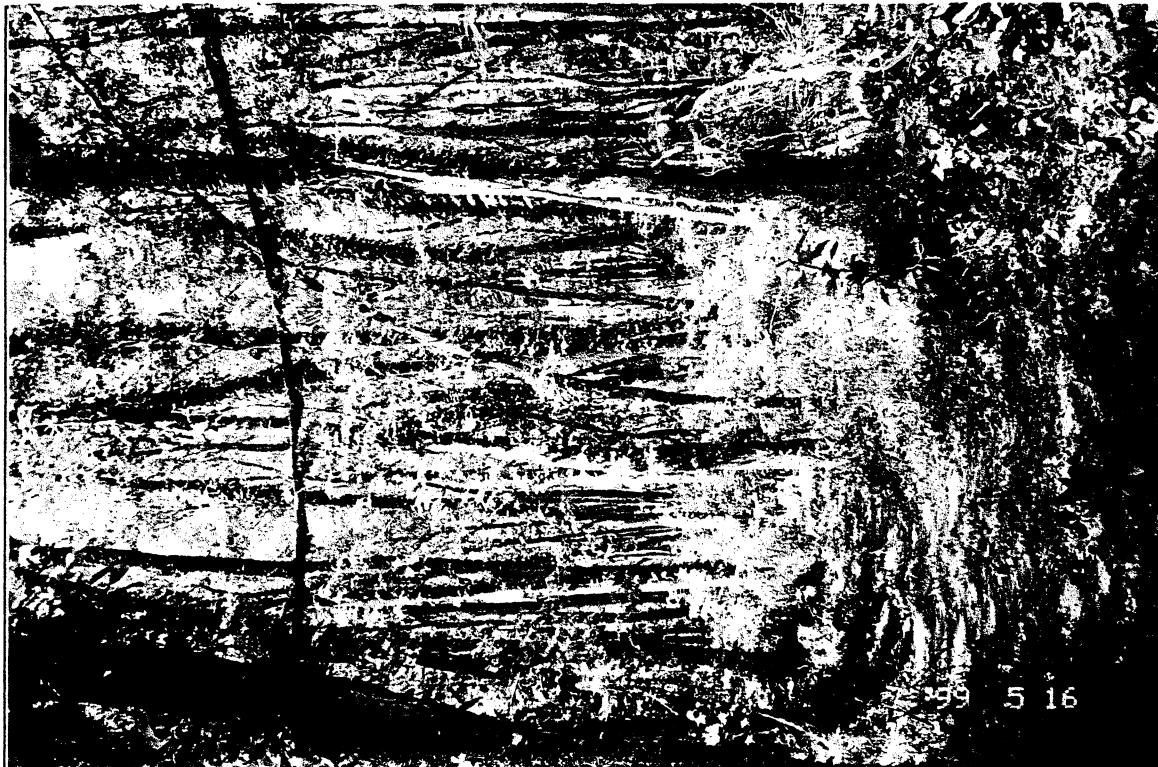
Three big brown bats (*Eptesicus fuscus*) were captured within the proposed project area. This species is common throughout North America. It ranges throughout the United States from Alaska and Canada to Mexico and South America. Big brown bats do not migrate; there appears to be no difference in range from summer to winter (Barbour and Davis 1969). The big brown bat is found throughout Kentucky during all seasons (Barbour and Davis 1974). It is commonly found in buildings, but also is known to roost in rock crevices, expansion joints of bridges and dams, and hollow trees.

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Appendix A

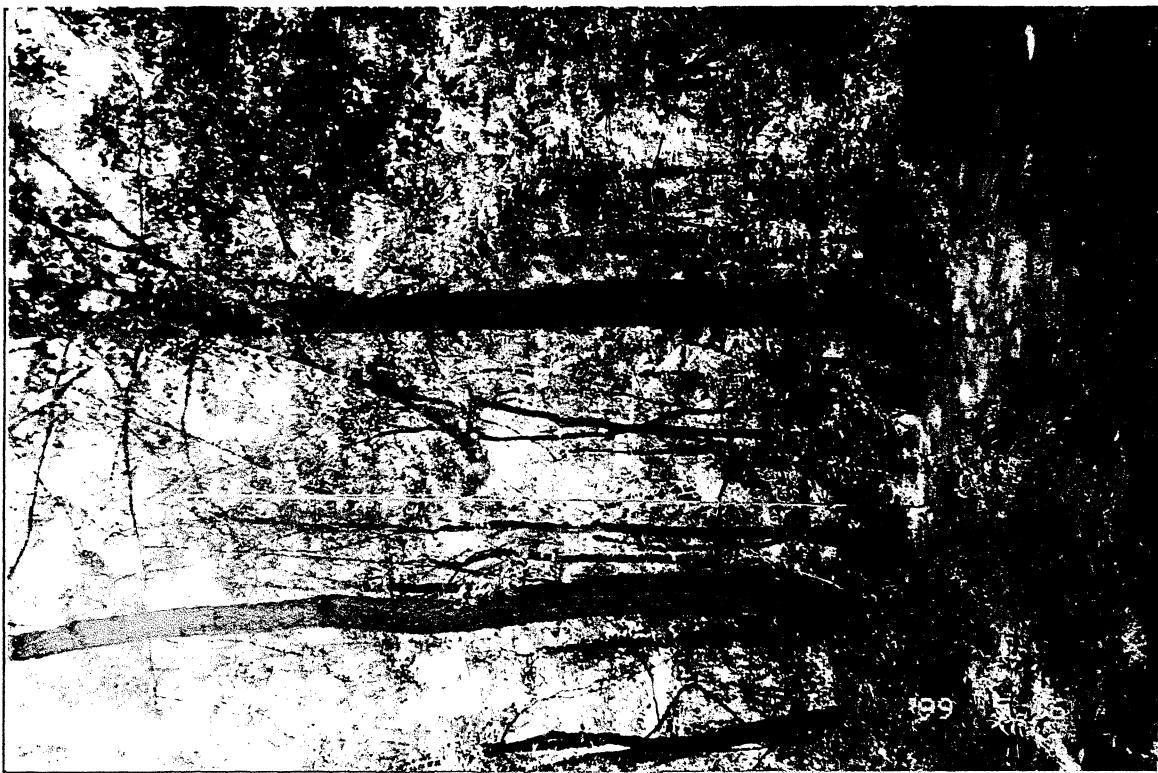
Photographs



Mist Net Site 1B



Mist Net Site 1A



Mist Net Site 2B



Mist Net Site 2A



Gray's Branch, facing upstream



Gray's Branch, facing downstream



Greenup Locks and Dam



Greenup Dam Recreation Area

APPENDIX D

**COE UNPUBLISHED REPORT -
TERRESTRIAL INVENTORY FOR GREENUP LOCKS AND DAM**

Terrestrial Habitat Description

Northern Scrub- On September 8, 1998 the northernmost extreme of Corps property was surveyed for terrestrial habitats and a species inventory was completed. Temperatures remained in the mid-70's °F throughout the day with full sun and little wind. A typical fall day. Full precipitation and weather data is available from the National Weather Service for this region. The entire area surveyed measured little more than 1.5 acres and was a disturbed woodland. For ease of narrative description, the area was divided into two communities. The attached species inventory is for both communities.

A gravel driveway bisected the area running south to north. This roadway was an access drive for fisherman using the bank of the Ohio River for angling. The road terminated at the northern edge of this woodland, and Corps property.

The area west of this roadway was sparsely occupied by a 15-20 year old stand of trees and their constituents. The canopy was dominated by specimens of wild black cherry, *Prunus serotina* (20%), black locust, *Robina pseudo-acacia* (40%), silver maple, *Acer saccharinum* (5%) and American sycamore, *Platanus occidentalis* (5%). As given by the percent cover, much of the site remained open beneath these young trees. Though not well developed, an understory of American elm, *Ulmus americana*, and wild black cherry had generated under the open canopy. Disturbance and the sparsity of cover had allowed a dense herbaceous layer to form. The dominants formed nearly monotypic patches of poison ivy, *Toxicodendron radicans* (80%), deer tongue grass *Panicum clandestinum* (10%), and stinging nettle, *Urtica dioica* (5%). This woodland community was surrounded by natural gas transmission easements and mowed fields. The woodland was therefore fringed with successional assemblages of wingstem *Verbesina alternifolia*, blackberry *Rubus* spp., and staghorn sumac *Rhus typhina* in monotypic patches.

The area east of the roadway was dominated by 10-15 year old sycamore (30%), boxelder, *Acer negundo* (10%), and black locust (10%). This woodland community was also very open with a developing understory of boxelder (5%), black locust (5%) and wild black cherry (<5%). Silver maple were also prominent in the understory near the banks of the Ohio River. The herbaceous community profited from the loose canopy and created nearly impassable patches of wingstem (30%), *Brachyelytrum*, *Brachyelytrum erectum* (20%), giant goldenrod, *Solidago gigantea* (10%) and woodland sunflower *Helianthus divaricatus* (5%) monocultures. Virginia rye, *Elymus virginicus* and poison ivy were also in evidence throughout the community. The community was edged with hay fields on the north and south, a roadway on the west, and the Ohio River to the east. Thickets of woodland sunflower, wingstem, staghorn sumac, and pokeweed *Phytolacca americana* edged this community on all sides.

This site was generally, and in some locations steeply, sloping toward the Ohio River. The eastern half of the community was covered with large sandstone rip-rap to protect the banks from erosion. Below the rip-rap a mud-flat had developed along the banks of the Ohio River owing to sustained low water conditions. Blunt-spine rush, *Eleocharis obtusa* had created a carpet of lush vegetation that was being used by a killdeer *Charadrius vociferus*, the day of the survey. The habitat is no doubt extremely ephemeral and the only terrestrial habitat used during this survey by vertebrate wildlife. Otherwise the area provided little in the way of quality terrestrial habitats and no aquatic or wetland habitats. An abandoned trash dump along the access road provided the only apparent denning opportunities in this otherwise droughty, uniform landscape. Occasional fallen logs may provide additional sites for small mammals and herptiles. However, the bunchy vegetative monocultures that dominate these very open woods do not seem to lend themselves to diverse vertebrate communities. No vertebrate use was observed by sight or sign during the survey (excepting 1 killdeer). Adjacent hay fields showed evidence of large mammal traffic, probably deer. No scat or former rubs were observed.

Species Observed: Sept. 8, 1998

Birds

Charadrius vociferus Killdeer

Herbaceous Plants

| | |
|--------------------------------|---------------------------------|
| <i>Agrostis alba</i> | redtop |
| <i>Ambrosia artemisiifolia</i> | common ragweed |
| <i>Amphicarpa bracteata</i> | hog peanut |
| <i>Asclepias syriaca</i> | milkweed |
| <i>Aster spp.</i> | aster |
| <i>Bidens ceruna</i> | nodding bur marigold |
| <i>Boehmeria cylindrica</i> | false nettle |
| <i>Brachyelytrum erectum</i> | |
| <i>Campsis radicans</i> | trumpet vine |
| <i>Cassia fasciculata</i> | wild sensitive plant |
| <i>Chenopodium album</i> | lamb's quarter |
| <i>Cyperus strigosus</i> | galingale |
| <i>Daucus carota</i> | Queen Anne's lace |
| <i>Desmodium spp.</i> | sticktight |
| <i>Digitaria ischaemum</i> | smooth crabgrass |
| <i>Eleocharis obtusa</i> | blunt spikerush |
| <i>Eleusine indica</i> | goose grass |
| <i>Elymus virginicus</i> | Virginia wild rye |
| <i>Eupatorium fistulosum</i> | common Joe-pye weed |
| <i>Eupatorium rugosum</i> | white snakeroot |
| <i>Geum canadense</i> | white avens |
| <i>Gnaphalium obtusifolium</i> | cudweed |
| <i>Helianthus divaricatus</i> | woodland sunflower |
| <i>Helianthus tuberosus</i> | Jerusalem artichoke |
| <i>Ipomoea lacunosa</i> | small-flowered morning glory |
| <i>Lactuca biennis</i> | blue lettuce |
| <i>Lactuca canadensis</i> | horseweed |
| <i>Leersia oryzoides</i> | rice cutgrass |
| <i>Lespedeza cuneata</i> | lespedeza |
| <i>Medicago sativa</i> | alfalfa |
| <i>Menispermum canadense</i> | moonseed |
| <i>Mimulus ringens</i> | common monkey- flower |
| <i>Panicum clandestinum</i> | deertongue grass |
| <i>Phytolacca americana</i> | pokeweed |
| <i>Polygonum pensylvanicum</i> | pennsylvania smartweed |
| <i>Polygonum scandens</i> | wild buckwheat |
| <i>Rosa multiflora</i> | multiflora rose |

Rubus occidentalis

black raspberry

Rubus spp.

blackberry

Setaria faberii

yellow foxtail

Setaria glauca

green foxtail

Setaria viridis

green foxtail

Solidago gigantea

giant goldenrod

Sorghum halepense

johnsongrass

Urtica dioica

stinging nettle

Verbesina alternifolia

wingstem

Veronica serpyllifolia

thyme-leaved

speedwell

Woody Plants

Acer negundo

boxelder

Acer saccharinum

silver maple

Ailanthus altissima

tree-of-heaven

Amorpha fruticosa

false indigo

Carya cordiformis

bitternut hickory

Carya laciniosa

shellbark hickory

Juglans nigra

black walnut

Morus alba

white mulberry

Platanus occidentalis

American sycamore

Populus deltoides

cottonwood

Prunus serotina

wild black cherry

Quercus muehlenbergii

chinquapin oak

Quercus velutina

black oak

Rhus typhina

staghorn sumac

Robinia pseudo-acacia

black locust

Toxicodendron radicans

poison ivy

Ulmus americana

American elm

cattail

| | |
|-------------------------------|---------------|
| <i>Uniola latifolia</i> | |
| <i>Verbascum thapsus</i> | mullein |
| <i>Verbena urticifolia</i> | white vervain |
| <i>Verbesina alternifolia</i> | wingstem |
| <i>Vernonia gigantea</i> | ironweed |

Woody Plants

| | |
|----------------------------------|-------------------|
| <i>Acer negundo</i> | boxelder |
| <i>Acer saccharinum</i> | silver maple |
| <i>Amorpha fruticosa</i> | false indigo |
| <i>Cephalanthus occidentalis</i> | buttonbush |
| <i>Fraxinus pennsylvanica</i> | green ash |
| <i>Platanus occidentalis</i> | American sycamore |
| <i>Populus deltoides</i> | cottonwood |
| <i>Prunus serotina</i> | wild black cherry |
| <i>Rhus glabra</i> | smooth sumac |
| <i>Rhus typhina</i> | staghorn sumac |
| <i>Robinia pseudo-acacia</i> | black locust |
| <i>Salix nigra</i> | black willow |
| <i>Toxicodendron radicans</i> | poison ivy |
| <i>Ulmus americana</i> | American elm |
| <i>Vitis vulpina</i> | winter grape |

Terrestrial Habitat Description

Open Fields- On September 15 & 17, 1998 the open fields within Corps property were surveyed for terrestrial habitats and a species inventory was completed. Temperatures remained in the low-90's °F on the 15th and the mid-80's °F on the 17th and little wind. Full precipitation and weather data is available from the National Weather Service for this region. Much of the area of the Corps lands at Greenup Locks & Dam were composed of open fields that were mowed frequently enough to maintain various herbaceous successional stages. The area surveyed covered the majority of Corps property and measured more than ??? acres. Included in this habitat type are successional fields following a natural gas transmission line within Corps property, and maintained fields around the lock & dam maintenance facility. The area, though all open herbaceous communities, varied in it's successional status. For ease of narrative description, the area was loosely divided into three communities. The attached species inventory is for the entire area.

Gasline right-of-way between the access road and the banks of the Ohio formed a consistent herbaceous community approximately 150 feet wide and 200+ feet long. This habitat is bordered by immature woodlands on the north and south, the Ohio River on the east, and a gravel access road on the west. The site was a disturbed sand and gravel soil. Gasline placement among other disturbances had left an undulating land surface that gently sloped toward the Ohio River. The actual bank of the river was rip-rapped with medium sandstone boulders. The vegetative community was in a late stage of herbaceous succession. Dominants included giant goldenrod(%), johnsongrass(%) and lespedeza(%). Black locust, sumac and false indigo, *Amorpha fruticosa* occurred sparsely in this herbaceous stand. The community was edged with sumac thickets.

Gasline right-of-way west and north of the access formed an "L" shaped community with the long axis oriented along a north-south trajectory. This community is distinguished by its lack of topographic relief and its mid-successional vegetative status. Further, the dominance of johnsongrass and lespedeza gives way to large monotypic patches of switchgrass, *Panicum virgatum*(%). Codominants included giant goldenrod (%). The thick stands of switchgrass may indicate a different management regime from the area near the Ohio River. Whatever the case, this clump-forming grass would provide thick nesting and escape cover for small mammals and avifauna. No encounters were recorded during the September surveys.

Blackberry and smooth sumac, *Rhus glabra* formed thickets along the edge of this linear openland, 200-300 feet wide. The transmission line traveled west away from the Ohio River before it met a north-south running trunkline. This transmission facility opened a slightly broader corridor in the surrounding woodlands. The vegetative community, however, remained essentially unchanged along much of the trunkline. Near the southern terminus of this main trunkline on Corps property the land surface became more undulating with a return of lespedeza(%), wingstem(%), sticktight(%), and deertongue grass(%). Giant goldenrod (%) remained among the dominants of this late successional community. Switchgrass became rather sparse in this small stretch of open land. Grease grass, *Triodia flava*, New England aster, *Aster novae-angliae*, and heath aster, *Aster pilosus* were among the conspicuous minority of the site. This community was largely impassable due to this thick, somewhat diverse herbaceous community.

Near the southern terminus of the Gas Transmission right-of-way on Corps lands, a gasline transmission maintenance facility was located along the access road near a sharp eastward bend in the road. This facility was graveled, with a large section of the transmission line above the surface of the ground for access. A potential jurisdiction wetland habitat was identified along the eastern edge of successional habitats near this facility, north of the access road (see Figure 1). This depressional habitat occurred 150-200 feet north of the road and was no more than 0.1 acre in arial extent. Dominants included rice cut-grass, *Leersia oryzoides*(%), boneset, *Eupatorium perfoliatum*(%), and narrowleaf cat-tail, *Typha angustifolia*(%). Water plantain, *Allisma subcordatum* and arrowleaf, *Sagittaria latifolia*. were minority constituents restricted to tire ruts in the center of the depression. Hydrology was confirmed in clear wetland drainage patterns and desiccated vegetation. Soils were not determined.

Species Observed: Sept. 15, 1998 (Open fields)

Herbaceous Plants

| | |
|--------------------------------|-----------------------|
| <i>Achillea millefolium</i> | yarrow |
| <i>Agrostis alba</i> | redtop |
| <i>Allisma subcordatum</i> | common water plantain |
| <i>Ambrosia artemisiifolia</i> | common ragweed |
| <i>Ambrosia trifida</i> | giant ragweed |
| <i>Andropogon virginicus</i> | broom-sedge |
| <i>Apcynum cannabinum</i> | indian hemp |
| <i>Asclepias syriaca</i> | milkweed |
| <i>Aster novae-angliae</i> | New England aster |
| <i>Aster pilosus</i> | heath aster |
| <i>Bidens ceruna</i> | nodding bur marigold |
| <i>Bidens coronata</i> | tickseed sunflower |
| <i>Bidens frondosa</i> | beggar's tick |
| <i>Boehmeria cylindrica</i> | false nettle |
| <i>Campsis radicans</i> | trumpet vine |
| <i>Carex frankii</i> | sedge |
| <i>Cassia fasciculata</i> | wild sensitive plant |
| <i>Cichorium intybus</i> | chicory |
| <i>Cirsium vulgare</i> | thistle |
| <i>Cirsium arvense</i> | Canada thistle |
| <i>Clematis virginiana</i> | virgin's bower |
| <i>Conium maculatum</i> | poison hemlock |
| <i>Convolvulus arvensis</i> | field bindweed |
| <i>Convolvulus sepium</i> | hedge bindweed |
| <i>Coronilla varia</i> | crown vetch |
| <i>Cyperus strigosus</i> | galingale |
| <i>Dactylis glomerata</i> | orchardgrass |
| <i>Daucus carota</i> | Queen Anne's lace |
| <i>Desmodium perplexum</i> | sticktight |
| <i>Digitaria ischaemum</i> | smooth crabgrass |
| <i>Diodia teres</i> | buttonweed |
| <i>Echinocloa crusgalli</i> | barnyard grass |
| <i>Eleusine indica</i> | goose grass |
| <i>Elymus virginicus</i> | Virginia wild rye |
| <i>Eupatorium aromaticum</i> | small white snakeroot |
| <i>Eupatorium coelestinum</i> | mistflower |
| <i>Eupatorium fistulosum</i> | common Joe-pye-weed |
| <i>Eupatorium perfoliatum</i> | boneset |
| <i>Euphorbia maculata</i> | spotted spurge |
| <i>Festuca pratensis</i> | meadow fescue |
| <i>Gnaphalium obtusifolium</i> | cudweed |
| <i>Helianthus tuberosus</i> | Jerusalem artichoke |

| | |
|--------------------------------|------------------------------|
| <i>Hibiscus moscheutos</i> | swamp rose-mallow |
| <i>Impatiens capensis</i> | spotted jewelweed |
| <i>Ipomoea lacunosa</i> | small-flowered morning glory |
| <i>Lactuca biennis</i> | blue lettuce |
| <i>Lactuca canadensis</i> | horseweed |
| <i>Leersia oryzoides</i> | rice-cutgrass |
| <i>Lespedeza cuneata</i> | lespedeza |
| <i>Lobelia siphilitica</i> | great blue lobelia |
| <i>Lonicera japonica</i> | Japanese honeysuckle |
| <i>Lycopus americanus</i> | water horehound |
| <i>Medicago sativa</i> | alfalfa |
| <i>Melilotus officinalis</i> | yellow sweetclover |
| <i>Menispernum canadense</i> | moonseed |
| <i>Muhlenbergia schreberi</i> | nimblewill |
| <i>Oenothera biennis</i> | evening primrose |
| <i>Panicum agrostoides</i> | redtop panic-grass |
| <i>Panicum clandestinum</i> | deertongue grass |
| <i>Panicum virgatum</i> | switchgrass |
| <i>Pastinaca sativa</i> | parsnip |
| <i>Phleum pratense</i> | timothy |
| <i>Phytolacca americana</i> | pokeweed |
| <i>Plantago lanceolata</i> | English plantain |
| <i>Plantago rugelii</i> | common plantain |
| <i>Polygonum pensylvanicum</i> | pennsylvania smartweed |
| <i>Polygonum scandens</i> | wild buckwheat |
| <i>Rosa multiflora</i> | multiflora rose |
| <i>Rubus occidentalis</i> | black raspberry |
| <i>Rubus</i> spp. | blackberry |
| <i>Sagittaria latifolia</i> | duck potato |
| <i>Sambucus canadensis</i> | common elderberry |
| <i>Saponaria officinalis</i> | soapwort |
| <i>Scirpus validus</i> | soft-stem bulrush |
| <i>Scutellaria lateriflora</i> | mad-dog skullcap |
| <i>Setaria faberii</i> | |
| <i>Setaria viridis</i> | green foxtail |
| <i>Solanum carolinense</i> | horse nettle |
| <i>Solidago gigantea</i> | giant goldenrod |
| <i>Sorghum halepense</i> | johnsongrass |
| <i>Spartina pectinata</i> | prairie cordgrass |
| <i>Strophostyle helvola</i> | trailing wild bean |
| <i>Tragopogon pratensis</i> | yellow goatsbeard |
| <i>Trifolium pratense</i> | red clover |
| <i>Triodia flava</i> | grease grass |
| <i>Typha angustifolia</i> | narrow-leaved |

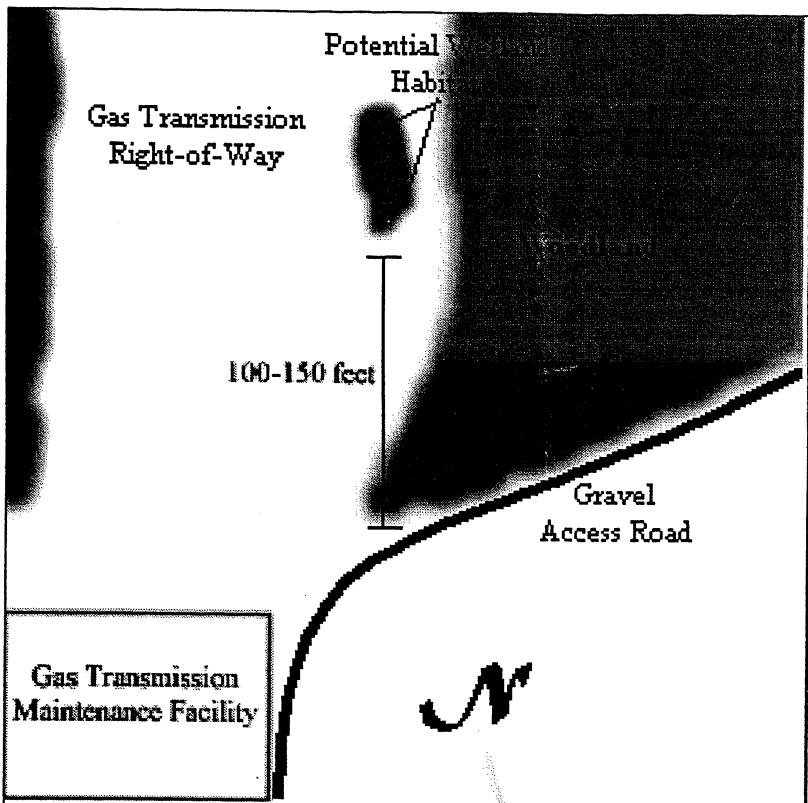


Figure 1- A map of the area containing potential jurisdictional wetlands near the gas transmission maintenance facility, Greenup Locks & Dam.

Open fields surrounding the Lock & Dam maintenance facility were disposed above the surrounding floodplains on a broad flat plateau of spoil material. This site was dominated by pasture varieties including meadow fescue, *Festuca pratense* (%), red clover, (%), and orchardgrass, *Dactylis glomerata* (%). During these fall surveys, warm season varieties were apparent including grease grass, ironweed, and tickseeds. The site was maintained with regular mowing. The only vegetative variety on the site was offered by patches of annual grasses (*Setaria* spp.) and rutted areas harboring nodding bur marigold.

APPENDIX E

**ORSANCO INFORMATION -
AQUATIC SAMPLING ON OHIO RIVER**



Objective:

Characterize the diversity and distribution of fish in the Ohio River.

Program Description:

Fish population studies have been a major component of ORSANCO monitoring activities for almost 20 years. From 1975 until 1992, lockchamber studies were conducted in cooperation with state and federal environmental and fisheries agencies. Beginning in 1990, electrofishing was added in order to expand the types of habitats which could be studied. In 1993, lockchamber studies were suspended in order to devote more resources to data assessment. Electrofishing has now become the primary means utilized by the Commission to study fish populations in the Ohio River.

The focus of the electrofishing effort in recent years has been towards the collection of adequate data for development of biological criteria. In FY96, the emphasis was on additional development of the electrofishing method in order to allow a better understanding of the results. In FY97, the Commission will resume pool-specific population studies. One pool in the upper river (Hannibal) and one pool in the lower river (Smithland) will be studied. It is the intent of the Commission to conduct intensive surveys of each navigation pool of the river in order to better understand the geographic variation in fish assemblages.

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[\[ORSANCO Home Page\]](#)- [\[Biological Programs\]](#)



Objective:

Characterize benthic macroinvertebrate populations at fixed stations in the Ohio River.

Program Description:

Macroinvertebrate populations provide additional perspective on aquatic life conditions in the river. Because many species are highly sensitive to pollution, and because they are relatively immobile, the assessment of macroinvertebrate populations can bring valuable insights on water quality. The Commission has conducted macroinvertebrate sampling each year since 1990. To date, resource limitations have precluded extensive analysis of the results.

During the summer of 1997, ORSANCO expanded its macroinvertebrate sampling efforts. With funding provided by USEPA and guidance from a panel of macroinvertebrate experts, ORSANCO set forth to expand its macroinvertebrate program.

Concern has been expressed that continued proliferation of zebra mussels in the Ohio River could preclude the use of artificial substrates as a means of collecting macroinvertebrate samples. ORSANCO field crews encountered some problems with zebra mussel infestation of samplers in FY96. Should the situation worsen, alternative approaches will have to be pursued. Barring any such difficulties, collection of macroinvertebrate samples will continue in FY97. Sampling locations utilized for fish population studies will also be used for macroinvertebrates. Analysis of the samples will be performed by a contractor.

[\[ORSANCO Home Page\]](#)- [\[Biological Programs\]](#)

| Pool | Order | Family | Subfamily | Genus |
|---------|----------------|--------------|--------------|------------------|
| GREENUP | AMPHIPODA | GAMMARIDAE | | GAMMARUS |
| GREENUP | AMPHIPODA | GAMMARIDAE | | GAMMARUS |
| GREENUP | AMPHIPODA | GAMMARIDAE | | GAMMARUS |
| GREENUP | BASOMMATOPHORA | ANCYLIDAE | | FERRISSIA |
| GREENUP | BASOMMATOPHORA | PHYSIDAE | | PHYSELLA |
| GREENUP | BASOMMATOPHORA | PLANORBIDAE | | MENETUS |
| GREENUP | BIVALVIA | | | |
| GREENUP | CLADOCERA | SIDIIDAE | | SIDA |
| GREENUP | COLEOPTERA | | | |
| GREENUP | COLEOPTERA | DRYOPIDAE | | HELICHUS |
| GREENUP | COLEOPTERA | DRYOPIDAE | | HELICHUS |
| GREENUP | COLEOPTERA | ELMIDAE | | DUBIRAPHIA |
| GREENUP | COLEOPTERA | ELMIDAE | | MACRONYCHUS |
| GREENUP | COLEOPTERA | ELMIDAE | | STENELMIS |
| GREENUP | COLEOPTERA | ELMIDAE | | STENELMIS |
| GREENUP | DIPTERA | CHIRONOMIDAE | | |
| GREENUP | DIPTERA | CHIRONOMIDAE | | ABLABESMYIA |
| GREENUP | DIPTERA | CHIRONOMIDAE | | CHIRONOMUS |
| GREENUP | DIPTERA | CHIRONOMIDAE | | CRICOTOPUS |
| GREENUP | DIPTERA | CHIRONOMIDAE | | CRICOTOPUS |
| GREENUP | DIPTERA | CHIRONOMIDAE | | CRICOTOPUS |
| GREENUP | DIPTERA | CHIRONOMIDAE | | CRICOTOPUS |
| GREENUP | DIPTERA | CHIRONOMIDAE | | CRYPTOCHIRONOMUS |
| GREENUP | DIPTERA | CHIRONOMIDAE | | DICROTENDIPES |
| GREENUP | DIPTERA | CHIRONOMIDAE | | DICROTENDIPES |
| GREENUP | DIPTERA | CHIRONOMIDAE | | GLYPTOTENDIPES |
| GREENUP | DIPTERA | CHIRONOMIDAE | | MICROTENDIPES |
| GREENUP | DIPTERA | CHIRONOMIDAE | | NANOCLADIUS |
| GREENUP | DIPTERA | CHIRONOMIDAE | | PARACHIRONOMUS |
| GREENUP | DIPTERA | CHIRONOMIDAE | | PARAKIEFFERIELLA |
| GREENUP | DIPTERA | CHIRONOMIDAE | | PHAENOPSECTRA |
| GREENUP | DIPTERA | CHIRONOMIDAE | | POLYPEDILUM |
| GREENUP | DIPTERA | CHIRONOMIDAE | | POLYPEDILUM |
| GREENUP | DIPTERA | CHIRONOMIDAE | | POLYPEDILUM |
| GREENUP | DIPTERA | CHIRONOMIDAE | | POLYPEDILUM |
| GREENUP | DIPTERA | CHIRONOMIDAE | | PSEUDOCHIRONOMUS |
| GREENUP | DIPTERA | CHIRONOMIDAE | | STENOCHIRONOMUS |
| GREENUP | DIPTERA | CHIRONOMIDAE | | TANYTARSUS |
| GREENUP | DIPTERA | CHIRONOMIDAE | | TRIBELOS |
| GREENUP | DIPTERA | CHIRONOMIDAE | CHIRONOMINAE | |
| GREENUP | DIPTERA | CHIRONOMIDAE | CHIRONOMINAE | CLADOTANYTARSUS |
| GREENUP | DIPTERA | CHIRONOMIDAE | CHIRONOMINAE | DICROTENDIPES |
| GREENUP | DIPTERA | CHIRONOMIDAE | CHIRONOMINAE | DICROTENDIPES |
| GREENUP | DIPTERA | CHIRONOMIDAE | CHIRONOMINAE | DICROTENDIPES |
| GREENUP | DIPTERA | CHIRONOMIDAE | CHIRONOMINAE | DICROTENDIPES |
| GREENUP | DIPTERA | CHIRONOMIDAE | CHIRONOMINAE | GLYPTOTENDIPES |
| GREENUP | DIPTERA | CHIRONOMIDAE | CHIRONOMINAE | PARACHIRONOMUS |

| | | | | |
|---------|---------------|---------------|----------------|------------------|
| GREENUP | DIPTERA | CHIRONOMIDAE | CHIRONOMINAE | PARACHIRONOMUS |
| GREENUP | DIPTERA | CHIRONOMIDAE | CHIRONOMINAE | PHAENOPSECTRA |
| GREENUP | DIPTERA | CHIRONOMIDAE | CHIRONOMINAE | POLYPEDILUM |
| GREENUP | DIPTERA | CHIRONOMIDAE | CHIRONOMINAE | POLYPEDILUM |
| GREENUP | DIPTERA | CHIRONOMIDAE | CHIRONOMINAE | POLYPEDILUM |
| GREENUP | DIPTERA | CHIRONOMIDAE | CHIRONOMINAE | POLYPEDILUM |
| GREENUP | DIPTERA | CHIRONOMIDAE | CHIRONOMINAE | POLYPEDILUM |
| GREENUP | DIPTERA | CHIRONOMIDAE | CHIRONOMINAE | POLYPEDILUM |
| GREENUP | DIPTERA | CHIRONOMIDAE | CHIRONOMINAE | PSEUDOCHIRONOMUS |
| GREENUP | DIPTERA | CHIRONOMIDAE | CHIRONOMINAE | RHEOTANYTARSUS |
| GREENUP | DIPTERA | CHIRONOMIDAE | CHIRONOMINAE | RHEOTANYTARSUS |
| GREENUP | DIPTERA | CHIRONOMIDAE | CHIRONOMINAE | STENOCHIRONOMUS |
| GREENUP | DIPTERA | CHIRONOMIDAE | CHIRONOMINAE | TANYTARSUS |
| GREENUP | DIPTERA | CHIRONOMIDAE | CHIRONOMINAE | TANYTARSUS |
| GREENUP | DIPTERA | CHIRONOMIDAE | CHIRONOMINAE | TRIBELOS |
| GREENUP | DIPTERA | CHIRONOMIDAE | ORTHOCLADIINAE | CRICOTOPUS |
| GREENUP | DIPTERA | CHIRONOMIDAE | ORTHOCLADIINAE | CRICOTOPUS |
| GREENUP | DIPTERA | CHIRONOMIDAE | ORTHOCLADIINAE | NANOCLADIUS |
| GREENUP | DIPTERA | CHIRONOMIDAE | ORTHOCLADINAЕ | |
| GREENUP | DIPTERA | CHIRONOMIDAE | TANYPODINAE | |
| GREENUP | DIPTERA | CHIRONOMIDAE | TANYPODINAE | ABLABESMYIA |
| GREENUP | DIPTERA | CHIRONOMIDAE | TANYPODINAE | ABLABESMYIA |
| GREENUP | DIPTERA | CHIRONOMIDAE | TANYPODINAE | ABLABESMYIA |
| GREENUP | DIPTERA | CHIRONOMIDAE | TANYPODINAE | COELOTANYPUS |
| GREENUP | DIPTERA | CHIRONOMIDAE | TANYTARSINI | |
| GREENUP | DIPTERA | EMPIDIDAE | | HEMERODROMIA |
| GREENUP | EPHEMEROPTERA | BAETIDAE | | BAETIS |
| GREENUP | EPHEMEROPTERA | CAENIDAE | | CAENIS |
| GREENUP | EPHEMEROPTERA | CAENIDAE | | CAENIS |
| GREENUP | EPHEMEROPTERA | HEPTAGENIIDAE | | |
| GREENUP | EPHEMEROPTERA | HEPTAGENIIDAE | | STENACRON |
| GREENUP | EPHEMEROPTERA | HEPTAGENIIDAE | | STENACRON |
| GREENUP | EPHEMEROPTERA | HEPTAGENIIDAE | | STENONEMA |
| GREENUP | EPHEMEROPTERA | HEPTAGENIIDAE | | STENONEMA |
| GREENUP | EPHEMEROPTERA | HEPTAGENIIDAE | | STENONEMA |
| GREENUP | EPHEMEROPTERA | TRICORYTHIDAE | | TRICORYTHODES |
| GREENUP | HAPLOTAXIDA | NAIDIDAE | | |
| GREENUP | HAPLOTAXIDA | NAIDIDAE | | DERO |
| GREENUP | HAPLOTAXIDA | NAIDIDAE | | NAIS |
| GREENUP | HAPLOTAXIDA | NAIDIDAE | | NAIS |
| GREENUP | HAPLOTAXIDA | NAIDIDAE | | NAIS |
| GREENUP | HAPLOTAXIDA | TUBIFICIDAE | | |
| GREENUP | HIRUDINEA | | | |
| GREENUP | HIRUDINEA | PISCICOLIDAE | | MYZOBDELLA |
| GREENUP | HYDROIDA | CLAVIDAE | | CORDYLOPHORA |
| GREENUP | HYDROIDA | HYDRIDAE | | HYDRA |
| GREENUP | LYMNOPHILA | ANCYLIDAE | | |
| GREENUP | LYMNOPHILA | PHYSIDAE | | |
| GREENUP | LYMNOPHILA | PHYSIDAE | | PHYSA |

| | | | | |
|---------|----------------|-------------------|--|----------------|
| GREENUP | LYMNOPHILA | PLANORBIDAE | | MENETUS |
| GREENUP | MEGALOPTERA | SIALIDAE | | SIALIS |
| GREENUP | MESOGASTROPODA | HYDROBIIDAE | | |
| GREENUP | MESOGASTROPODA | HYDROBIIDAE | | SOMATOGYRUS |
| GREENUP | MESOGASTROPODA | PLEUROCERIDAE | | ELIMIA |
| GREENUP | MESOGASTROPODA | PLEUROCERIDAE | | LITHASIA |
| GREENUP | MESOGASTROPODA | PLEUROCERIDAE | | PLEUROCERA |
| GREENUP | NEMATODA | | | |
| GREENUP | NEMATODA | MERMITHIDAE | | |
| GREENUP | NEUROPTERA | SISYRIDAE | | CLIMACIA |
| GREENUP | ODONATA | COENAGRIONIDAE | | |
| GREENUP | ODONATA | COENAGRIONIDAE | | ARGIA |
| GREENUP | ODONATA | COENAGRIONIDAE | | ARGIA |
| GREENUP | ODONATA | COENAGRIONIDAE | | ENALLAGMA |
| GREENUP | ODONATA | CORDULIIDAE | | NEUROCORDULIA |
| GREENUP | ODONATA | CORDULIIDAE | | NEUROCORDULIA |
| GREENUP | ODONATA | CORDULIIDAE | | NEUROCORDULIA |
| GREENUP | ODONATA | MACROMIIDAE | | MACROMIA |
| GREENUP | OLIGOCHAETA | | | |
| GREENUP | TRICHOPTERA | | | |
| GREENUP | TRICHOPTERA | BRACHYCENTRIDAE | | MICRASEMA |
| GREENUP | TRICHOPTERA | HYDROPSYCHIDAE | | |
| GREENUP | TRICHOPTERA | HYDROPSYCHIDAE | | CHEUMATOPSYCHE |
| GREENUP | TRICHOPTERA | HYDROPSYCHIDAE | | HYDROPSYCHE |
| GREENUP | TRICHOPTERA | HYDROPTILIDAE | | |
| GREENUP | TRICHOPTERA | HYDROPTILIDAE | | HYDROPTILA |
| GREENUP | TRICHOPTERA | HYDROPTILIDAE | | OXYETHIRA |
| GREENUP | TRICHOPTERA | LEPTOCERIDAE | | NECTOPSYCHE |
| GREENUP | TRICHOPTERA | LEPTOCERIDAE | | NECTOPSYCHE |
| GREENUP | TRICHOPTERA | POLYCENTROPODIDAE | | |
| GREENUP | TRICHOPTERA | POLYCENTROPODIDAE | | CYRNELLUS |
| GREENUP | TRICHOPTERA | POLYCENTROPODIDAE | | CYRNELLUS |
| GREENUP | TRICHOPTERA | POLYCENTROPODIDAE | | NEURECLIPSIS |
| GREENUP | TRICLADIDA | | | |
| GREENUP | TRICLADIDA | PLANARIIDAE | | DUGESIA |
| GREENUP | TUBIFICIDA | TUBIFICIDAE | | |
| GREENUP | VENEROIDA | CORBICULIDAE | | CORBICULA |
| GREENUP | VENEROIDA | DREISSENIIDAE | | DREISSENA |

| Species |
|-----------------------|
| FASCIATUS |
| FASICATUS |
| SP. |
| RIVULARIS |
| SP. |
| DILATATUS |
| SP. |
| CRYSTALLINA |
| SP. |
| LITHOPHILUS |
| SP. |
| SP. |
| GLABRATUS |
| HUMEROSEA-SINUATA GR. |
| SP. |
| SP. |
| MALLOCHI |
| SP. |
| BICINCTUS |
| SP. |
| SYLVESTRIS |
| TREMULUS |
| VIERRIENSIS |
| SP. |
| NEOMODESTUS |
| NERVOSUS |
| SP. |
| SP. |
| DISTINCTUS |
| SP. |
| BATHOPHILA |
| SP. |
| HALTERALE |
| ILLINOENSE |
| ILLINOENSE GR. |
| SCALAENUM |
| SP. |
| SP. |
| SP. |
| FUSCICORNE |
| SP. |
| MANCUS GR. |
| LUCIFER |
| NEOMODESTUS |
| NERVOSUS |
| SP. |
| SP. |
| ABORTIVUS |

| |
|----------------|
| SP. |
| SP. |
| CONVICTUM |
| HALTERALE |
| ILLINOENSE |
| SCALAENUM |
| SP. |
| SP. |
| EXIGUUS GR. |
| SP. |
| SP. |
| GUERLUS GR. |
| SP. |
| FUSCICORNE |
| BICINCTUS GR. |
| SP. |
| SP. |
| SP. |
| SP. |
| JANTA |
| MALLOCHI |
| SP. |
| AMICA |
| SP. |
| SP. |
| GILDERSLEEVEI |
| INTERPUNCTATUM |
| SP. |
| INTEGRUM |
| SP. |
| TERMINATUM |
| SP. |
| SP. |
| SP. |
| COMMUNIS |
| PARDALIS |
| SP. |
| SP. |
| SP. |
| LUGUBRIS |
| LACUSTRIS |
| SP. |
| SP. |
| SP. |
| SP. |

| |
|------------|
| DILATATUS |
| SP. |
| SP. |
| SP. |
| SP. |
| OBOVATA |
| SP. |
| SP. |
| SP. |
| SP. |
| TIBIALIS |
| SP. |
| OBSOLETA |
| MOLESTA |
| OBSOLETA |
| SP. |
| CANDIDA |
| SP. |
| SP. |
| FRATERNUS |
| SP. |
| SP. |
| SP. |
| TIGRINA |
| SP. |
| FLUMINEA |
| POLYMORPHA |

APPENDIX F
TERRESTRIAL/AQUATIC HABITAT PHOTOGRAPHS

LIST OF PHOTOGRAPHS

AQUATIC AND TERRESTRIAL INVENTORY GREENUP LOCKS AND DAM HABITAT PHOTOGRAPHS MAY 1999

- 1 Overview of open field habitat looking north.
- 2 Close up of open field habitat looking west.
- 3 Overview of southern portion of riparian forest habitat looking south. Note relatively young cover types.
- 4 Overview of northern portion of riparian forest habitat. Note more mature plant growth.
- 5 Overview of riverbank habitat looking south.
- 6 Close up of riverbank habitat. Note predominance of willow and pioneer species.
- 7 Overview of upstream riverine habitat looking north.
- 8 Overview of upstream riverine habitat looking south. Note extensive overhanging vegetation/woody debris along shoreline.
- 9 Overview of downstream riverine habitat looking north.
- 10 Overview of downstream riverine habitat in vicinity of pipeline crossing.
- 11 Overview of backwater habitat located south of dam. Note extensive shoreline vegetation at northern extent.
- 12 Overview of backwater habitat located north of dam looking south.



Photograph 1: Overview of open field habitat looking north.



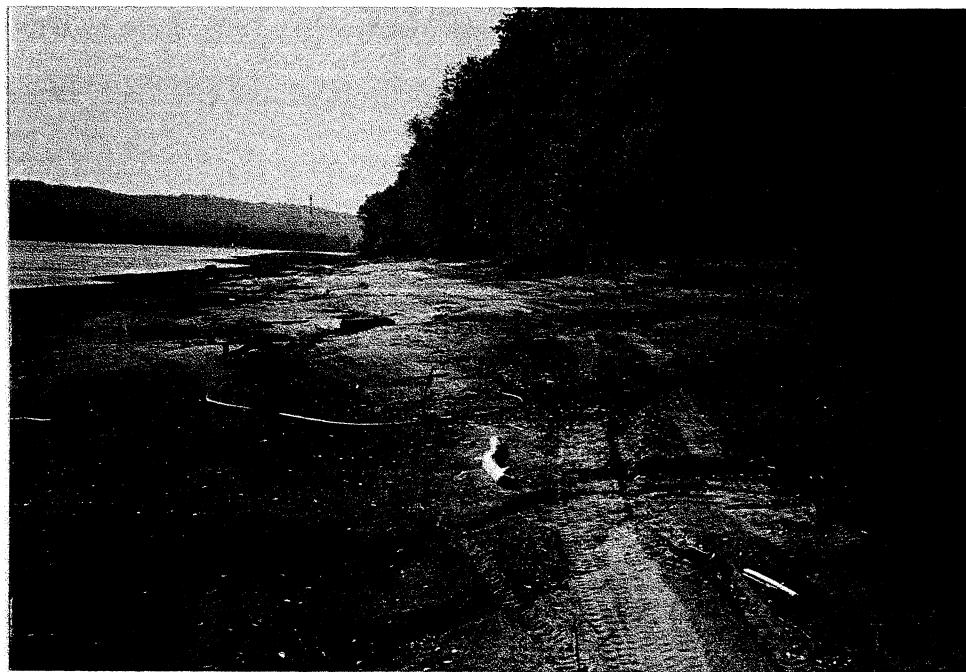
Photograph 2: Close up of open field habitat looking west.



Photograph 3: Overview of southern portion of riparian forest habitat looking south. Note relatively young cover types.



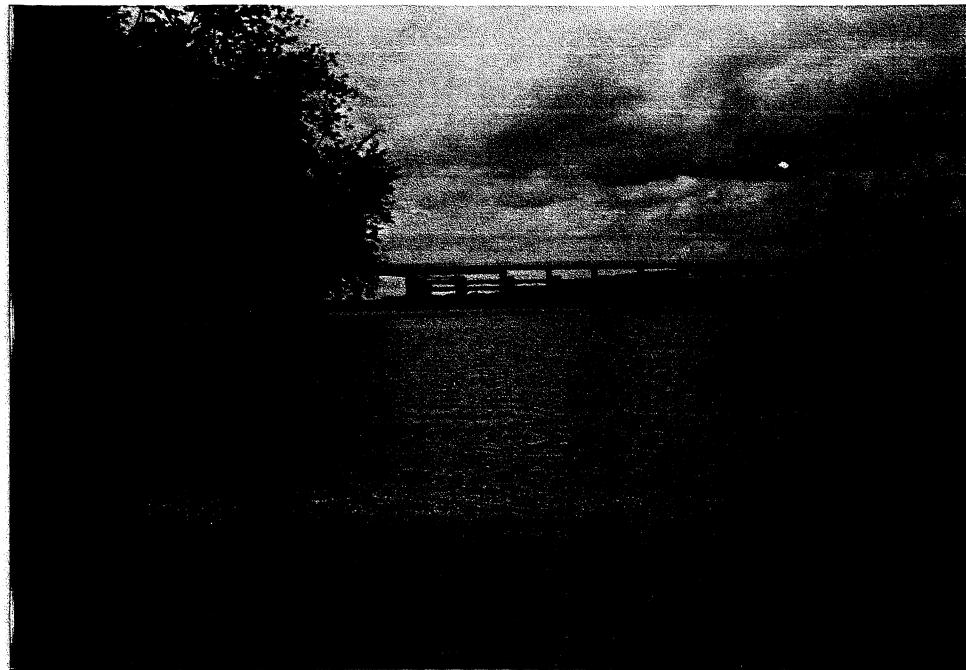
Photograph 4: Overview of northern portion of riparian forest habitat. Note more mature plant growth.



Photograph 5: Overview of riverbank habitat looking south.



Photograph 6: Close up of riverbank habitat. Note predominance of willow and pioneer species.



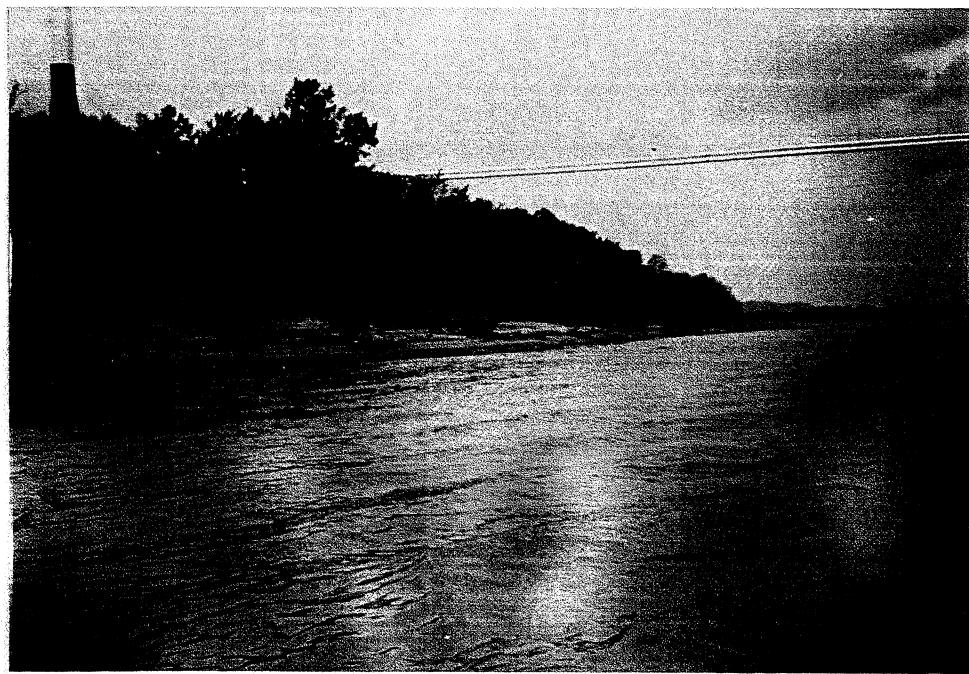
Photograph 7: Overview of upstream riverine habitat looking north.



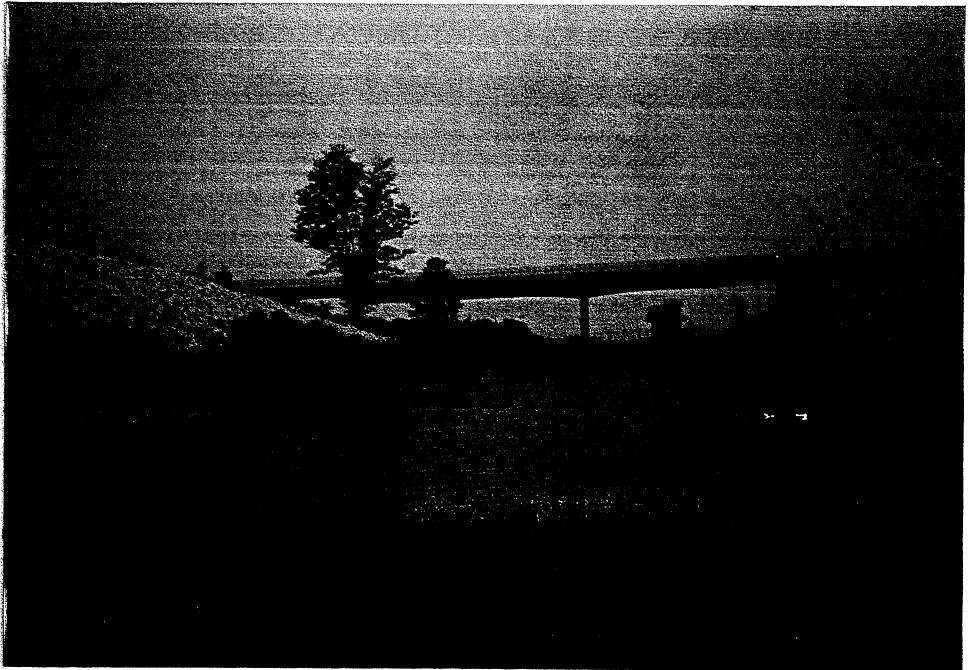
Photograph 8: Overview of upstream riverine habitat looking south. Note extensive overhanging vegetation/woody debris along shoreline.



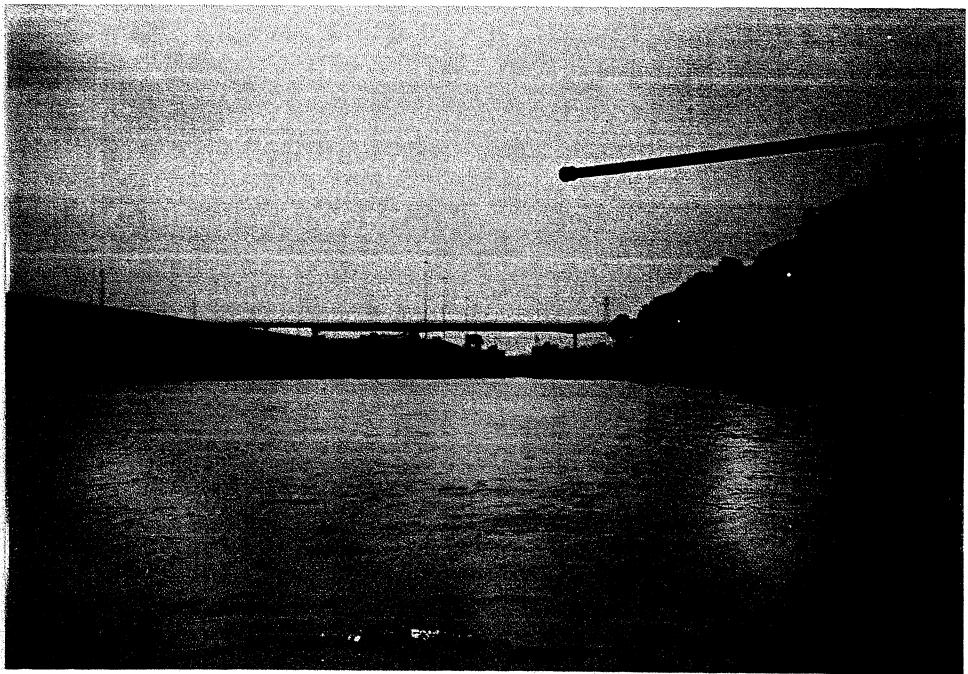
Photograph 9: Overview of downstream riverine habitat looking north.



Photograph 10: Overview of downstream riverine habitat in vicinity of pipeline crossing.



Photograph 11: Overview of backwater habitat located south of dam. Note extensive shoreline vegetation at northern extent.



Photograph 12: Overview of backwater habitat located north of dam looking south.

APPENDIX G
AQUATIC VOUCHER PHOTOGRAPHS

LIST OF PHOTOGRAPHS

AQUATIC INVENTORY GREENUP LOCKS AND DAM VOUCHER PHOTOGRAPHS MAY 1999

- 1 Channel Catfish
- 2 White/Striped Bass Hybrid
- 3 Golden Redhorse
- 4 Longnose Gar
- 5 Central Longear Sunfish
- 6 Pumpkinseed Sunfish
- 7 Northern Bluegill Sunfish
- 8 Freshwater Drum
- 9 Spotted Sucker
- 10 Skipjack Herring
- 11 Smallmouth Buffalofish
- 12 Highfin Carpsucker
- 13 Northern River Carpsucker
- 14 Black Redhorse
- 15 White Bass
- 16 Northern Largemouth Blackbass
- 17 Silver Chub
- 18 Common Emerald Shiners, Spotfin Shiners, Sand Shiners, River Shiners, Bluntnose Minnows, Spottail Shiners



1 - Channel Catfish

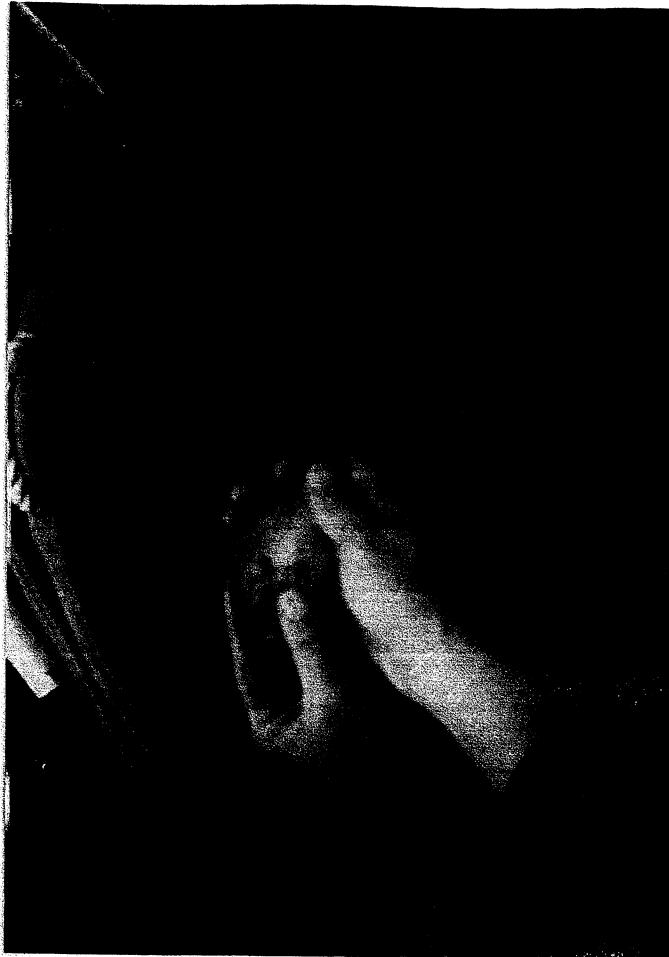


2 - White/Striped Bass Hybrid



3 - Golden Redhorse

4 - Longnose Gar



5 - Central Longear Sunfish



6 - Pumpkinseed Sunfish



7 - Northern Bluegill Sunfish

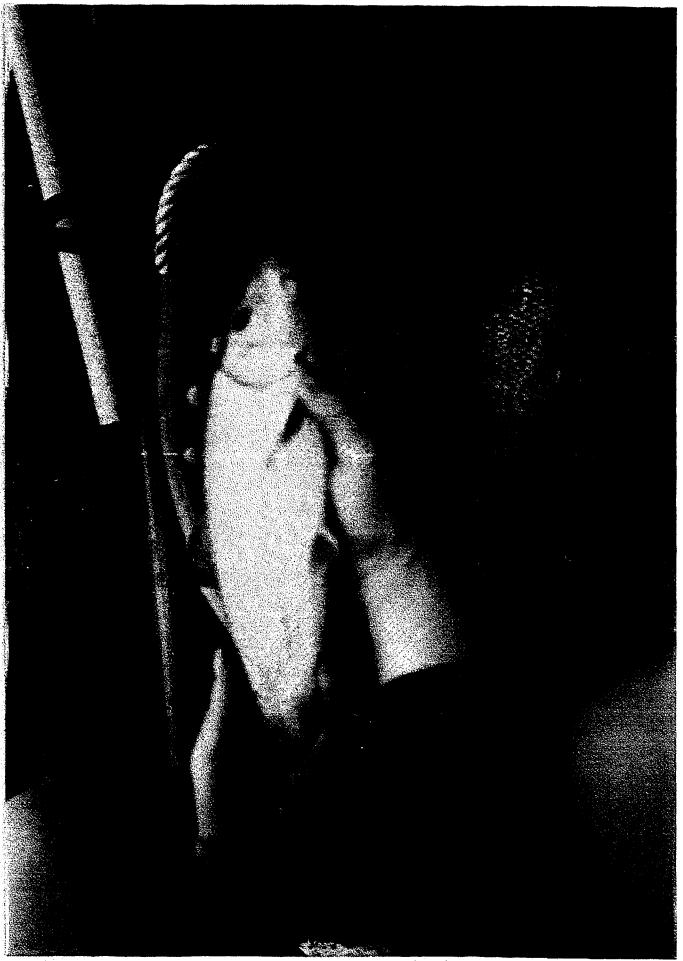
8 - Freshwater Drum



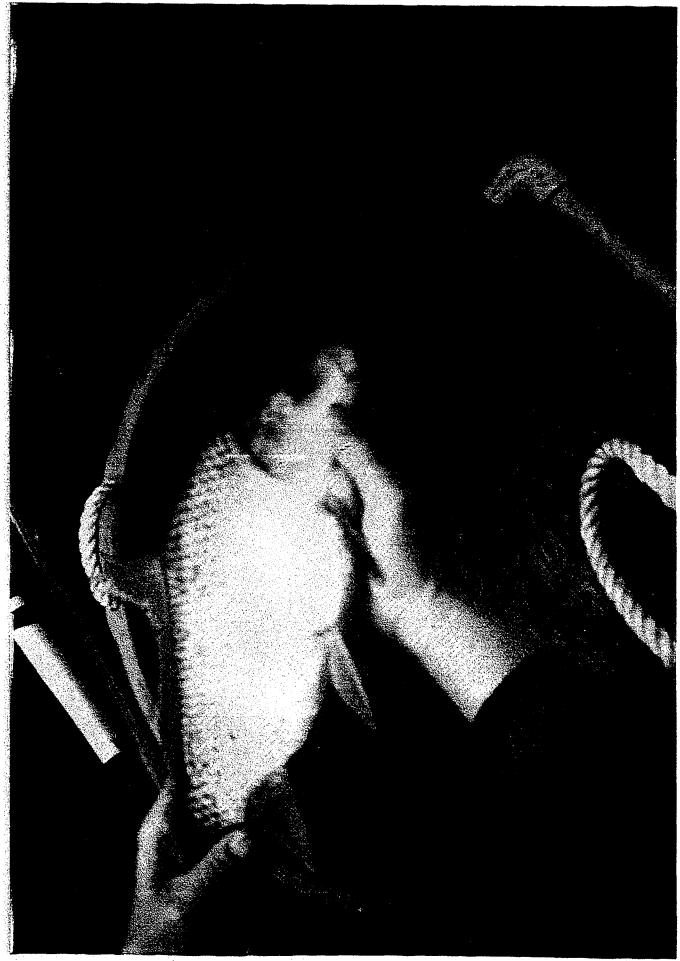
10 - Skipjack Herring



12 - Highfin Carpsucker



9 - Spotted Sucker



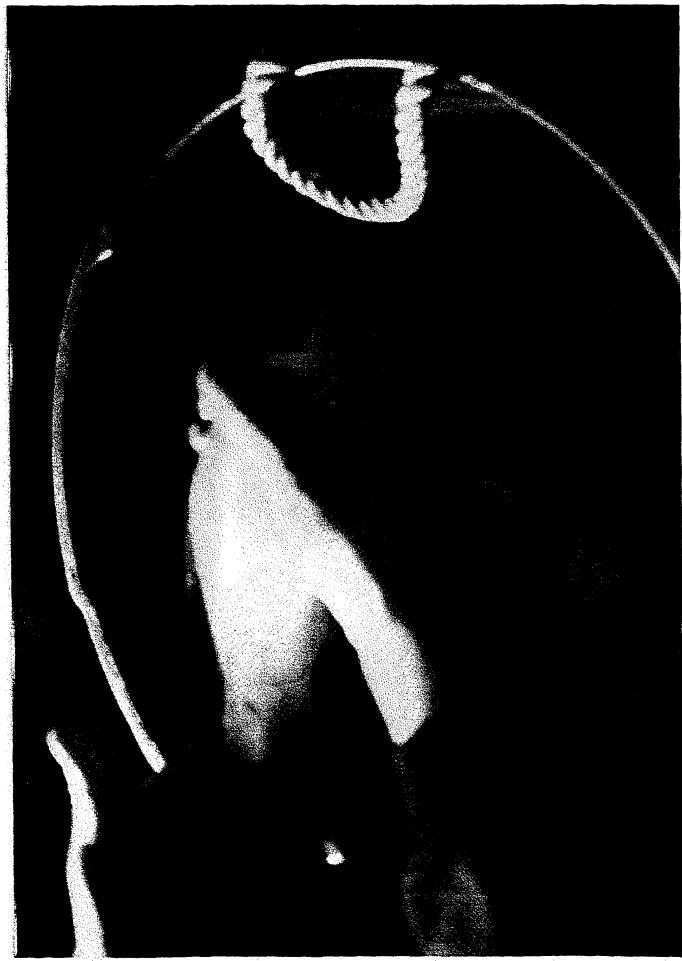
11 - Smallmouth Buffalo



14 - Black Redhorse



16 - Northern Largemouth Blackbass



13 - Northern River Carpsucker



Dace